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RESEARCH MEMORANDUM

RECRUITING EFFICIENCY AND ENLISTMENT OBJECTIVES: AN EMPIRICAL ANALYSIS

Patricia E. Byrnes
Timothy W. Cooke

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Subj: Center for Naval Analyses Research Memorandum 87-181

Encl: (1) CNA Research Memorandum 87-181, "Recruiting Efficiency and Enlistment Objectives: An Empirical Analysis," Sep 1987

1. Enclosure (1) is forwarded as a matter of possible interest.
2. This Research Memorandum examines the relative performance of recruiting districts from 1981 through 1985, and evaluates the consistency of the enlistment quotas assigned to districts during this period.

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RECRUITING EFFICIENCY AND ENLISTMENT OBJECTIVES: AN EMPIRICAL ANALYSIS

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Navy-Marine Corps Planning and Manpower Division

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ABSTRACT

With increasing accession requirements and a more competitive recruiting environment, the size of the enlisted recruiting force has grown substantially. The Center for Naval Analyses was asked to provide analytical support to Commander, Navy Recruiting Command (CNRC), concerning ways to improve the return on this recruiting investment by examining the geographic allocation of recruiters, goals, and incentives. This research memorandum reports on the empirical analysis of three questions: (1) How do recruiting districts compare in terms of past production? (2) Are geographic differences in enlistment goals consistent with measured differences in recruiting market conditions? (3) How can the results be used to better evaluate district recruit production?



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INTRODUCTION AND SUMMARY

BACKGROUND

Recently, Navy recruiters have faced more intense competition from the private sector and other sources than at any time since 1979. Moreover, the Youth Attitude Tracking Survey shows that after years of being the second most desirable service to potential recruits, the Navy has fallen below the Air Force and Army among those expecting to volunteer for military service. With increasing accession requirements and a tougher recruiting environment, Navy management has significantly increased the size of the enlisted recruiting force. In this context, the Center for Naval Analyses (CNA) was asked to provide analytical support to Commander, Navy Recruiting Command (CNRC), concerning ways to improve the return on this recruiting investment by examining the geographic allocation of recruiters, goals, and incentives. This research memorandum reports on the empirical analysis of three questions: (1) How do different recruiting districts compare in terms of past production after accounting for various factors affecting external enlistment opportunities? (2) Are geographic differences in enlistment goals consistent with measured differences in recruiting markets? (3) How can this analysis be used to better evaluate district recruit production?

DATA AND METHODOLOGY

The activities of recruiting districts are modeled as a production process where the output is total number of enlistments with high school diplomas in AFQT category III and above. The observable factors of production include the number of recruiters and the economic and demographic conditions in which the district operates. Relative district performance is gauged by comparing the actual number of contracts produced to an estimated maximum potential number of contracts that could be produced given the same recruiting environment.

Two approaches are used to estimate the maximum production levels and gauge the performance of the districts. The first approach is a nonstochastic, linear programming technique developed in the operations research literature [1, 2, and 3]. The other technique has been developed by econometricians and is explicitly stochastic and parametric [4]. The methods are compared, and an analysis of the similarities and differences establishes the robustness of the results. Both methods control for geographic differences in unemployment rates, recruit population size, relative military to civilian pay, and the extent of urbanization. The observations are yearly for Navy recruiting districts from FY 1981 through FY 1985.

RELATIVE RECRUITING PERFORMANCE: FY 1981 TO FY 1985

A comparison of the actual number of quality contracts to the estimated maximum production level revealed a significant improvement in performance over the period. FY 1984 and FY 1985 show a reduction of over 5 percentage points in the average difference between actual and estimated enlistments relative to FY 1981 and FY 1982. Because only quality contract production was analyzed, this reduction may be associated in part with an increase in the overall quality composition of contracts between FY 1982 and FY 1984. In addition, there were systematic differences in performance across recruiting areas. Districts in areas 1 (northeast) and 4 (north central) have been less effective in producing quality recruits than similar districts in other areas, other things being equal.

CONSISTENCY OF CONTRACT QUOTAS: FY 1982 TO FY 1985

The consistency of enlistment contract goals assigned to districts in a given year improved remarkably between FY 1982 and FY 1985. The number of districts with goals lower than other districts operating in similar environments (as characterized by economic and demographic conditions) fell by nearly 60 percent. Moreover, the average amount by which goals were set lower than similar districts decreased by 64 percent. The only significant inconsistency is that districts in area 1 (northeast) are more likely to have lower goals than similar districts in other areas. This appears to reflect relatively difficult recruiting in the Northeast that is not captured in the analysis.

IMPROVED PERFORMANCE MEASURES

Currently, recruiting districts are evaluated based on achievement of contract objectives. It is not always clear, however, whether expectations of recruiting opportunity have been accurately evaluated in the planning process. The empirical analysis in this research memorandum gauges district performance relative to other districts in similar circumstances. Improved evaluations of performance can be derived when such relative measures of performance are combined with information on goal attainment. A cross-classification of districts by relative efficiency and goal attainment can be used to suggest goal reallocations. For example, districts whose recent performance is less than that of similar districts, yet have attained their enlistment goals, are good candidates for goal increases. On the other hand, districts that produce at least as many contracts as other similar districts but are unable to meet their objectives are good candidates for goal reductions.

THE RECRUITING ENVIRONMENT

With the advent of the All-Volunteer Force nearly 15 years ago, recruiting of military personnel entered an era when successful attainment of recruiting objectives was threatened by the business cycle and its effects on the youth labor market. Declining attractiveness of military service in the late 1970s led to a deterioration in the ability of the services to enlist the desired quantity and quality of new recruits. Since that time, military service has been made more attractive to potential recruits. A combination of military pay raises, enlistment incentives, and recession in the civilian economy led to a substantial improvement in the number and quality of youths desiring to enlist in 1982 and 1983. Subsequently, recruiters have had continued success enlisting high-quality recruits, despite the continuing expansion of the civilian economy.

The services can influence the success of their recruiting efforts by altering the number of recruiters and advertising expenditures, as well as other recruiting resources. Several empirical studies of the relationship between aggregate recruiting resources, environmental variables, and the number and quality of enlistments have been conducted (see [5] through [10] for example). In each case, the recruiting process is modeled as a production relationship between recruiting resources (inputs) and the resulting number and types of recruits (outputs). Several features of the recruiting market, on both the supply and demand sides, result in a complex relationship between the factors of production and the output of the process. Each of the studies tends to treat one part of the complex relationship in more detail than the others. On the supply side, significant attention has been focused on the influence of quotas as a demand constraint on production. Various statistical techniques have been used to identify the supply of volunteers [7, 8]. On the demand side, the substitution possibilities between different types of recruits have been analyzed [9, 10]. The effects of recruiter incentives and the influence of interservice competition for recruits have also been considered [6, 8, and 9].

The primary focus of this study is to examine the relative effectiveness of Navy recruiting districts operating in similar environments.¹ Like previous studies, recruiting is modeled as a production process. One distinction between this study and the others is that rather than estimating an average production relationship, a production frontier is estimated. The performance measure compares the actual output produced to the imputed maximum output level.

1. See [11] for a nonstochastic analysis of the productive efficiency of Army recruiting battalions. For a study of productive efficiency in Navy recruiting, see [12].

The supply of recruits is determined by individual choices between military and civilian occupations. The primary cohort from which the Navy recruits non-prior-service individuals consists of 17-to 21-year-olds who are in the very early stages of their productive employment careers. The choice between civilian and military service employment opportunities can be analyzed in an opportunity cost framework. An individual is presumed to choose that employment for which the opportunity cost of not pursuing the alternative is the highest among the alternatives considered. These opportunity costs include the individual's evaluation of the nonpecuniary traits of the various offers. If the net taste for civilian employment, in monetary terms, is low relative to the net pecuniary advantage of a military enlistment contract, the individual is expected to choose a military offer. The aggregate of individual choices between military and civilian occupations is assumed to be determined by relative military compensation, unemployment prospects, demographic factors, and recruiting resources, particularly the number of recruiters.

The specification of the recruiting relation is:

$$ACCON_i = f(PAY_i, UN_i, POP_i, URBPCT_i, RTR_i) + \epsilon_i, \quad (1)$$

where the subscript i refers to the i th year district observation.

This postulated relationship includes labor market conditions (PAY, UN), Navy recruiting resources (RTR), and demographic characteristics of the district (POP, URBPCT). The number of recruits (ACCON) is measured by the total number of enlistment contracts (net of attrition from the Delayed Entry Program) for two types of individuals. The first are so-called A-cell contracts, representing high school diploma graduates testing in the upper half of the population on the Armed Forces Qualification Test (AFQT). Among the major recruit quality types, these are the most difficult to enlist. The other recruit type is the high school diploma graduate scoring in the fourth and fifth deciles on the AFQT. These are the so-called upper half of the C-cell recruit population. The sum of these two recruit types (A-cell and upper C-cell or CU-cell recruits) constitutes the measure of recruiting performance used in this study.

Relative military pay (PAY) and the youth unemployment rate (UN) are expected to be positively related to the number of such recruits. The youth population of A- and CU-cell individuals in each district during a year (POP), as well as percent urban population (URBPCT) are also expected to be associated with greater production of recruits of these types. Other things being equal, more recruiters (RTR) should

produce more recruits.¹ Of these determinants of high-quality contracts, only the number of recruiters is under the control of Navy planners. The rest are environmental variables thought to affect the productivity of recruiters.

1. It is usually postulated that recruit production is subject to diminishing returns with respect to the addition of recruiters. However, this should be observed only beyond the point at which the fixed inputs, say population, have become congested by the addition of more variable inputs, say recruiters. The evidence for such congestion is weak at the aggregate level. A large increase in the number of production recruiters in FY 1986 was not associated with a significant decline in the average number of male non-prior-service recruits per recruiter. Moreover, quality substitution between recruit types does not appear to account for the performance of these additional recruiters. Unobservable variation in recruiter effort may mask evidence of diminishing returns.

SPECIFICATION ISSUES

A number of issues arise in connection with the above specification of the production relation, but these issues differ from the usual concern for accurate identification of the effects of particular variables (or inputs) on contract production. It is not the purpose of this research to identify the magnitude of supply shifts associated with changes in environmental variables. Rather it is to estimate enlistment potential for a certain category of recruits across districts and over time and to use this information to help evaluate performance at the district level. Thus, the problem is more similar to reduced form forecasting than parameter identification in a structural model of recruit production.

OMITTED VARIABLES

Omitted variables bias is a primary concern in structural econometric models of recruiting markets. For prediction, however, the problem of omitted variables is less important than it otherwise would be if those variables are correlated in stable ways with the included variables. For example, consider the omission of advertising from the list of input variables. Past studies of military enlistments, including [6] but not [5], find that advertising has a relatively small positive effect on recruiting performance. Omitting advertising from the specification in equation 1 will generally bias the estimated coefficients of variables that are correlated with advertising expenditures. If advertising is positively correlated with the number of recruiters, the effect of changing recruiters on predicted contracts will be overestimated. Predicted enlistments will include the effects of changes in advertising; however, the predictions will have greater variance than a specification that has relevant omitted variables like advertising included.

Similar statements can be made about the linear programming approach to predicting production capability. If districts with many recruiters tend to have large advertising expenditures, the inclusion of recruiters alone will tend to capture production differences associated with advertising. Independent movements in advertising expenditures that affect production will not be properly accounted for in either the stochastic or linear programming approaches. In the case of advertising, additional measurement problems relate to its effect as a stock or a flow. These issues are addressed in [5]. Advertising expenditure is omitted from the specification in this analysis because data are available for only a portion of the sample period.

Variables reflecting changes in the resourcing of other military services are also not included due to lack of data. During the time period considered (FY 1981 through FY 1985), the Army increased the relative competitiveness of its offers to recruits through increases in

enlistment bonuses and educational benefits. Signs of more competitive Army enlistment incentives were a steady improvement in quality of Army enlistments over the period.¹

The Army enlistment bonus tests were conducted over a period of two years from mid-1982 to mid-1984, with bonuses varying geographically [14]. Those regions of the country offering an \$8,000 enlistment bonus for a four-year enlistment were found to have significant Army market expansion effects relative to control areas. Omission of a variable that might capture this effect may cause districts in affected areas to appear less productive than expected.

VARIABLE MEASUREMENT

In addition to the problem of omitted variables, there are difficult specification issues concerning the proper measurement of recruiting effort and conditions. One of these is the distinction between measurement of stocks and flows of resources. Is recruit production more closely related to the cumulative flow of recent recruiter effort or to the flow at a given time? The distinction is particularly important when there are significant changes in the number of recruiters during the period of observation. One way to avoid this problem is to lengthen the time period of each unit of observation, increasing the correlation between the stock and flow measures. The annual data used in this study represent such a compromise.

A second related problem has to do with the lag between circumstances leading to an enlistment and the resulting enlistment, i.e., the shorter the period of observation, the greater the importance of such lags. Using annual data probably incorporates most such effects within the unit of observation.

A third issue is the measurement error itself. Systematic measurement error is known to lead to coefficient bias. The instrumental variable approach to solving this problem increases the variance of parameter estimates in return for a decrease in bias. In general, such procedures are not expected to improve prediction accuracy. Though measurement errors are thought to be important for some of the included variables, a correction for measurement errors has not been attempted.

1. See the Youth Attitude Tracking study [13] for more detail on youth service preferences.

DEMAND CONSTRAINTS AND RECRUITER EFFORT

One of the empirical issues most intensively studied in the literature on recruiting is the effect of quotas or goals on production. If recruiters are given strong incentives to produce a minimum number of contracts and weaker incentives to exceed quotas, actual production may underestimate the supply potential of the district. In fact, using quotas to manage recruiting effort may be a significant source of underproduction relative to potential.¹ Accounting for this possibility usually involves some type of sample selection procedure. The objective of such procedures is to identify those districts where goals have had a restraining effect on production. Including a sample selection criterion in estimation allows better inferences to be drawn about the underlying production capability of districts.

In this study, the effects of demand constraints are avoided by considering only those recruit types considered limited in supply. The dependent variable or output measure includes only A-cell and CU-cell contracts. These are high school diploma graduates (HSDGs) in AFQT mental groups 3 and above. Two important groups of recruits forming the residual of the market are omitted. The two groups consist of high school diploma graduates scoring in the second and third deciles on the AFQT (the so-called CL-cell contracts) and non-high school diploma graduates (NHSDGs) scoring in the top half of the AFQT range (the so-called B-cell contracts). These recruits are generally the least desirable on survival and productivity grounds [15]. They tend to fill gaps between quotas (especially for accessions) and production of higher quality recruits. In the individual competition system, recruiters are given less credit for these recruits than for the A-cell and CU-cell recruits that are measured in the enlistment contract variable [16]. Including only A-cell and CU-cell contracts yields an analysis not likely to be affected by quotas.²

Associated with the economic recession beginning in 1982, Navy recruiters had an unexpected windfall of productive activity through 1983. Moreover, because of constraints on the management of the Delayed Entry Program (DEP), recruiting effort was scaled back in the latter part of 1983. This Navy policy decision negatively affected production in that year. The result was that recruiters produced fewer contracts than they could have in an unconstrained environment. Because of this policy, recruiting performance in FY 1983 is not expected to reflect production possibilities. (The average number of contracts per

1. Reference [7] identifies the inhibiting effect of quotas on production.
2. Earlier studies of recruiting concentrated on A-cell recruits to avoid the influence of demand constraints. As pointed out in [7], it may be desirable to plan for differences in recruit quality between areas.

recruiter in 1983 is only about 90 percent of the overall average.) The following section does not include FY 1983 recruiting performance.

DATA

Aggregate recruiting performance is analyzed at the district level. Navy Recruiting Command divides the U.S. into 41 recruiting districts designated by the city in which the district headquarters is located. Each district is under the command of one of six Navy Recruiting Area commanders. Figure 1 illustrates the location of recruiting districts and identifies each area. Table 1 lists the locations of district commands. These data consist of five yearly observations for each district operating in FY 1981 through FY 1985.

Beginning with the specification of the output of a district, data on the number of A- and CU-cell contracts are obtained from Commander, Navy Recruiting Command (CNRC), by way of the Defense Manpower Data Center (DMDC). These data are not available until one year after the end of the fiscal year, because DMDC tracks the DEP attrition of each individual enlistment contract to get a measure of net enlistment contracts. At this time, the latest available data are for FY 1985. Table 2 presents the mean and standard deviation (across recruiting districts) for this measure of production for each fiscal year separately. In FY 1981 and 1982, high school diploma graduates constituted less than 80 percent of accessions as opposed to more than 90 percent of accessions in FY 1983 and 1984 [15]. The substitution of high school diploma graduates for non-diploma recruits was made possible primarily by the economic recession. Declining numbers of A- and CU-cell recruits in 1984 and 1985 reflect a decline in the number of recruiters and better civilian opportunities, as measured by the unemployment rate and employment cost index.

The number of on-board recruiters (RTR) includes production canvassers, supervisors, and others. Production canvassers dominate this total (about 90 percent). It does not include recruiter support personnel, such as classifiers who assign recruits to training slots. A comparison of the average number of recruiters per district across years reveals a significant decline in the number of recruiters in 1984. Unfortunately for Navy recruiting, this drop in recruiters coincided with falling unemployment rates in the civilian economy. The variance in number of recruiters per district has declined by about one-third since 1981. The source of these data is CNRC.

The average population of youths in the A- and CU-cell categories (POP) has declined monotonically over the years, and the variance has fallen slightly. These population statistics are provided to CNRC by a consulting concern. CNA obtained these data from CNRC.

1. The data set is contained in appendix A.

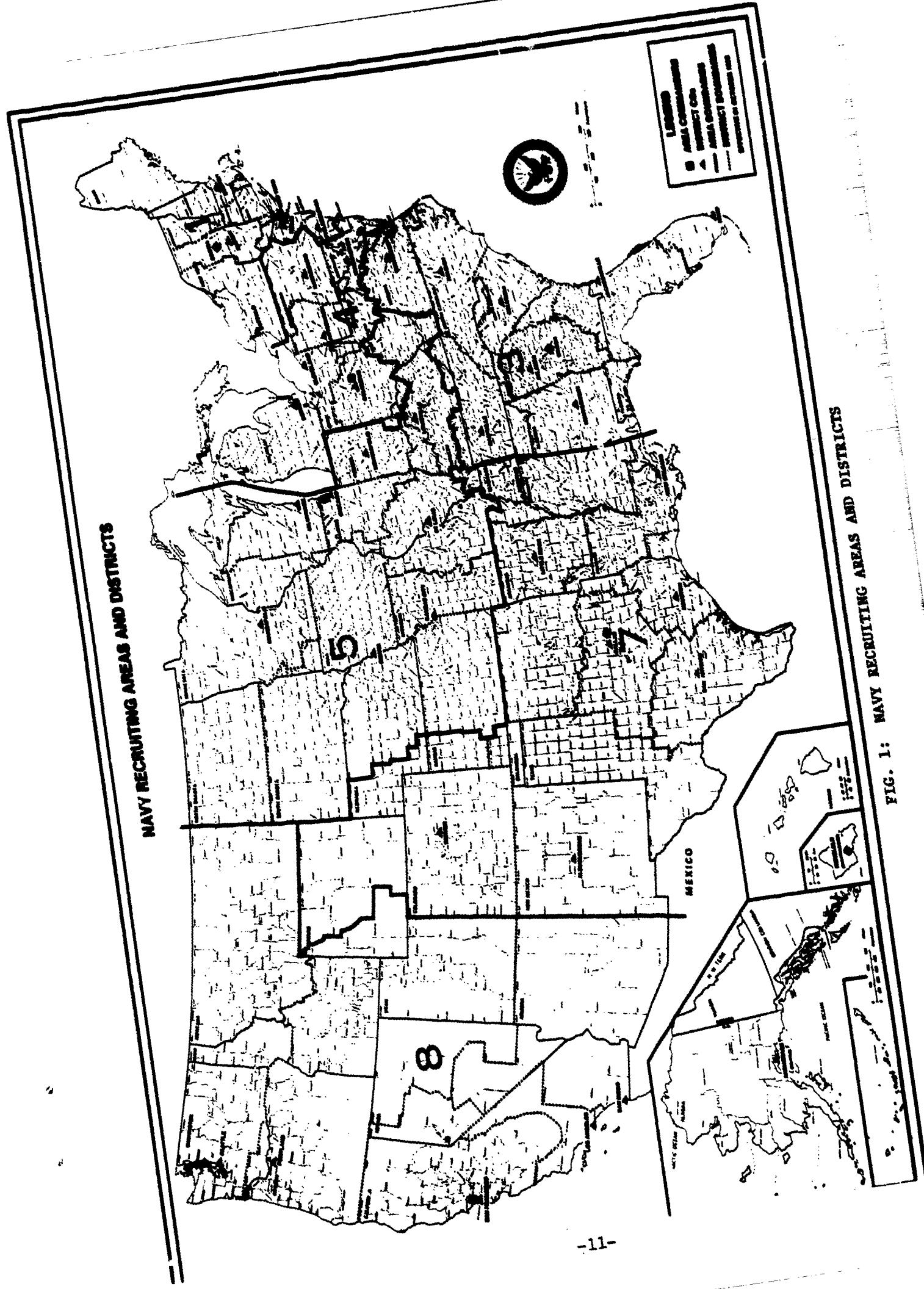


TABLE 1
NAVY RECRUITING DISTRICTS

<u>District</u>	<u>City</u>
101	Albany
102	Boston
103	Buffalo
104	New York
119	Philadelphia
161	New Jersey
310	Montgomery
311	Columbia
312	Jacksonville
313	Atlanta
314	Nashville
315	Raleigh
316	Richmond
348	Miami
406	Harrisburg
409	Washington
417	Cleveland
418	Columbus
420	Pittsburgh
422	Detroit
521	Chicago
524	St. Louis
526	Louisville
527	Kansas City
528	Minneapolis
529	Omaha
542	Indianapolis
559	Milwaukee
725	Denver
730	Albuquerque
731	Dallas
732	Houston
733	Little Rock
734	New Orleans
746	San Antonio
747	Memphis
836	Los Angeles
837	Portland
838	San Francisco
839	Seattle
840	San Diego

NOTE: The first digit of the district identifies the area the district is located. Area boundaries were reorganized in FY 1987 and new area identifiers listed. The reorganization resulted in five changes: district 406 was 105, 747 was 347, 526 was 407, 316 was 408, and 542 was 423.

TABLE 2
VARIABLE DESCRIPTIONS AND SUMMARY STATISTICS

NAME	DESCRIPTION	1981		1982		1983		1984		1985	
		MEAN	ST DEV								
ACCON	Number of A- and CU-cell contracts	1,131	412	1,299	435	1,414	439	1,205	367	1,260	347
RTR	Number of recruiters	92	31	88	27	99	26	83	24	87	25
POP	A- and CU-cell youth population	119,532	46,677	117,723	45,756	115,362	44,672	112,676	43,393	110,860	42,305
UR	Average unemployment rate (percentage)	7.3	1.5	9.0	2.0	10.2	2.4	7.8	1.9	7.3	1.7
URBPCT	Percent of district population urbanized (percentage)	73.3	16.6	73.3	16.6	73.4	16.6	73.4	16.5	73.4	16.4
PAY	Relative military pay index.	109.43	10.69	116.10	11.46	114.58	11.33	113.28	10.95	113.38	10.98
ATTN	Total number of contracts attained	2,508	904	2,694	863	2,165	663	1,982	582	1,976	554
GOAL	Total contract objectives.	na	na	2,517	865	2,074	629	1,940	654	2,112	610

The unemployment rate (UR) is the aggregate rate (not the youth rate) by Navy Recruiting District as computed by CNRC planners from Bureau of Labor Statistics data. As expected, the percent of population that is urbanized (URBPCT), as defined by the Census Bureau, is relatively constant over the years. There is, however, significant cross-section variation in each year, with a range of from 60 percent to 92 percent. These data are also from CNRC.

The relative military pay variable (PAY), defined as the ratio of military to civilian sector pay, has been constructed from two sources. The first source is a measure of cross-section variation in relative military pay in 1980 developed by CNA for use in [6]. The second is a time series of the Employment Cost Index (ECI) for each of four regions of the country. The original cross-section variation is based on estimates of the earnings of civilian youth by Navy Recruiting District. This measure of cross-section variation is then updated for each district by time series changes in the average cost of employing individuals in the private sector, as measured by the ECI. Each of the 41 districts is assigned to one of the four ECI regions for use in the computation of the relative military pay index.¹ Because only four regional values of the index are available, the cross-section variation in the growth rates is limited. Furthermore, it is possible that the ECI does not accurately measure changes in the civilian earning potential of 17-to-21-year-old men.

Table 3 describes the key environmental variables by Navy recruiting area. Districts in areas 1 and 8 have the largest and most urbanized recruitable population on average. Areas 4, 5, and 8 have, on average, the highest unemployment rates. Relative military pay is highest in area 3 and lowest in area 8. These area averages mask some differences between districts within the same area that are accounted for in the analysis.

1. There are a number of potential problems with the construction of this index. It is based on 1970 Census data on hourly earnings of youths, age 17 to 21, by county. This variable was updated to 1976 using the ratio of state to county hourly earnings. The 1980 cross section variation was obtained by applying national growth rates to the earlier numbers.
2. The 1980 data have 43 recruiting districts. For the purpose of assigning districts to the ECI regions, the two districts that do not appear in the 1981 through 1985 data are dropped from the analysis. They were incorporated into the remaining 41. No attempt has been made to adjust the FY 1980 geographic variation for changes in district boundaries.

TABLE 3
ENVIRONMENTAL VARIABLE SUMMARY STATISTICS BY AREA^a

Area (No. of obs.)	Mean (st. dev.)			
	POP	UR	URBPCT	PAY
1 (24)	144,218 (31,427)	6.9 (1.2)	91.3 (9.3)	116.50 (7.66)
3 (32)	79,250 (18,624)	7.6 (1.8)	69.6 (11.8)	126.63 (6.89)
4 (24)	126,360 (36,490)	9.6 (2.3)	79.3 (6.4)	113.07 (10.09)
5 (32)	119,180 (34,958)	8.1 (1.7)	61.1 (14.5)	108.69 (7.89)
7 (32)	81,778 (14,922)	7.2 (1.7)	66.2 (17.3)	107.16 (10.13)
8 (20)	171,596 (49,505)	8.2 (1.2)	82.0 (14.1)	103.55 (4.49)
Total (164)	115,198 (44,298)	7.9 (1.9)	73.4 (16.4)	113.05 (11.18)

^{a.} The 164 districts include the 41 districts operating in 1981, 1982, 1984, and 1985. These statistics exclude 1983.

THE CONCEPT OF TECHNICAL EFFICIENCY

The concept of technical efficiency is illustrated in figure 2 for the simple case of one input (x) used to produce one output (y). The production function $y = f(x)$ depicts the maximum output y obtainable from the various input levels or production plans. If a recruiting district is observed producing the maximal output given the level of inputs, it is said to be technically efficient. Otherwise, the district is characterized as technically inefficient. All districts operating on the curve $y = f(x)$ would be characterized as technically efficient. Those operating inside the frontier are labeled technically inefficient. The extent of technical efficiency is typically measured as the amount of output lost. For example, a district operating at point A in figure 2, producing y^A with x^A would be technically inefficient. The lost output is the difference in y^A and $y^* = f(x^A)$.

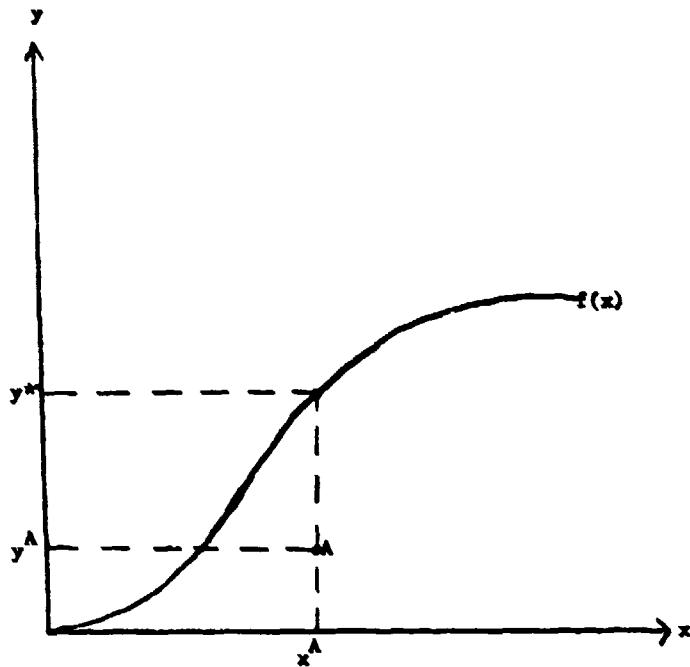


FIG. 2: PRODUCTION FUNCTION AND TECHNICAL EFFICIENCY

1. Technical efficiency can be measured as lost potential output (output technical efficiency) or wasted resources (input technical efficiency). The former, as depicted in figure 2, holds the level of inputs fixed and asks whether the observation is producing the maximum output for that level of inputs. The input technical efficiency measure treats the output level (rather than input level) fixed and asks whether the observation could have produced the same level of output with fewer resources.

Technical efficiency is only one sort of efficient behavior. Recruiting efficiency can also be assessed relative to the objective of benefit or value maximization. To be value maximizers, the recruiting operation must not only produce the maximal output given the level of inputs, i.e., be technically efficient, but also choose the appropriate mix of outputs given the relative value of the various outputs. The efficient choice of output mix given the values of various outputs is referred to as allocative efficiency. Allocative and technical efficiency together imply overall productive efficiency.

These efficiency concepts are illustrated in figure 3. Assume that each district produces two outputs, say A- and CU-cell recruit contracts, from a given level of inputs x^0 . The production possibilities set $P(x^0)$ gives the set of all A- and CU-cell contracts that can be produced from x^0 . All recruiting districts observed operating on and not inside the production possibilities frontier, for example points R and T, are technically efficient in the sense that they would be producing the maximum number of A- and CU-cell contracts given the level of inputs. Stated differently, the production possibilities frontier gives all points where no more of either recruit type could be obtained without giving up some of the other.

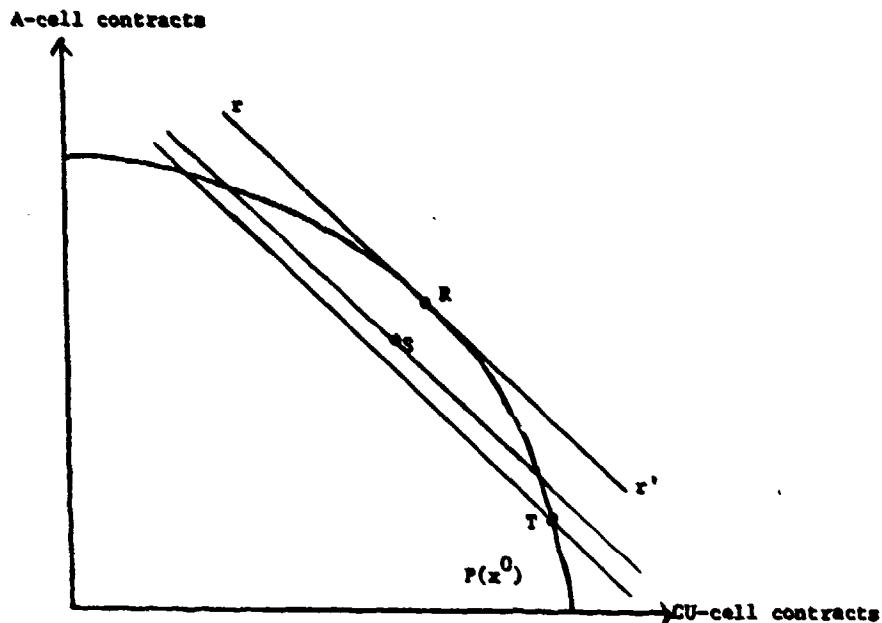


FIG. 3: OVERALL PRODUCTIVE, ALLOCATIVE, AND TECHNICAL EFFICIENCY MEASURES

The explicit recognition of relative values of the different types of recruits makes it possible to evaluate the different points on the frontier. Suppose the relative value of A- and CU-cell recruits to the Navy is represented by the slope of the line rr' . At point R, a district is producing the maximum output given the input level (technical efficiency) and is producing the combination of A- and CU-cell contracts that maximize the value of that recruit cohort to the Navy (allocative efficiency), given the resources and relative value of recruits.

Note that it is possible to be technically efficient but not allocatively efficient. For example, a district operating at point T is technically efficient, i.e., no more of either recruit type may be obtained without giving up some of the other. This combination of recruits, however, does not represent the most effective allocation of effort between recruit types. Given the relative value of the two types of contracts, the hypothetical district is producing too few A-cell contracts. In fact, production of the recruit combination S, though technically inefficient, is preferable to the combination at T.

In spite of the importance of producing the right combination of recruits, measurement of relative technical efficiency using a restrictive definition of output is the primary research focus. This reflects a large degree of uncertainty concerning the relative values of different recruit types.

1. The allocative efficiency of alternative mixes of recruit types can be evaluated if relative values can be assigned to these different types of recruits. In a study of Navy recruiter incentives [15], the relative values implied by recruiter rewards and first-term attrition data are discussed. These values could be used in analyzing allocative efficiency.

THE MEASUREMENT OF TECHNICAL EFFICIENCY

Measurement of technical efficiency involves two tasks. The first is characterization of the production environment in which technical efficiency will be gauged. This was done in equation 1. It remains to specify this relation as a production frontier that allows for the estimation of the maximal output obtainable given the resources and environment. Once this is accomplished, the performance or technical efficiency of the districts can be gauged relative to the frontier.

Two approaches to the specification of the frontier and measurement of efficiency relative to that technology are employed. The first approach, Data Envelopment Analysis (DEA), specifies a nonparametric, nonstochastic piecewise linear frontier and uses linear programming techniques to compute the technical efficiency measure. The second approach, referred to as the statistical approach, specifies a parametric, stochastic form of the production frontier and uses statistical regression techniques to estimate the parameters and measures of efficiency.

THE DEA APPROACH

This approach specifies a nonparametric, nonstochastic piecewise-linear technology to represent the production environment. It uses the piecewise linear representation of the technology as constraints in a linear programming (LP) problem whose solution provides a measure of technical efficiency. The LP problem is given in appendix B; a brief description of the measure and its properties is given here.

Figure 4 illustrates the piecewise linear technology T for the case of one output y produced by one input x . Suppose four activities (recruiting districts) are observed, represented by the four points (input-output combinations) labeled s , t , u , and v . The piecewise linear technology that bounds or envelops these data is bounded by tuv and the x -axis. The boundary of the set represents the estimated efficient frontier for this reference technology. All observations operating on the frontier are dubbed efficient or the "best practice" of the sample. Observations in the interior, like s , are labeled technically inefficient. Other things being equal, observation s is presumed capable of producing y^* , rather than y^S . The DEA technical efficiency measure increases the observed output level, say y^S for observation s , as much as possible while still staying in T at the given level of input (x^S). The measure can be thought of as the ratio of potential output y^* to actual observed output y^S so that $DEA^S = y^*/y^S$. For observations that make up the reference technology T , observed output is equal to the efficient output, and the DEA measure of technical efficiency is unity. For interior observations, the estimate is greater than one and gives the ratio of efficient output to actual output where efficient output is determined relative to the

constructed piecewise linear technology. One minus the DEA measure gives the proportion of output lost due to technical efficiency.

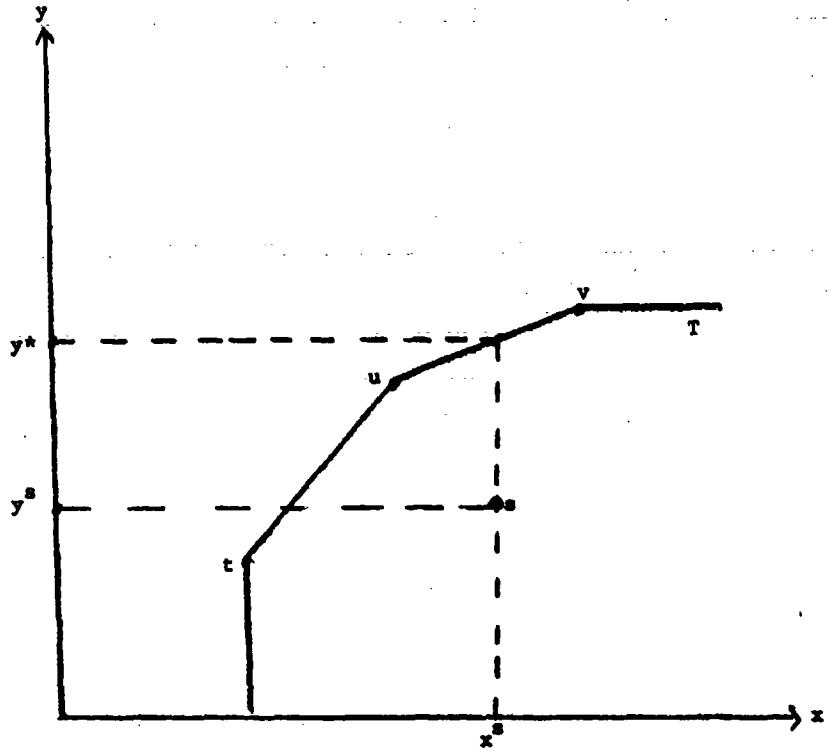


FIG. 4: DEA MEASURE OF TECHNICAL EFFICIENCY

To interpret the DEA results and compare the estimates to the statistical approach, several characteristics of the DEA estimates should be pointed out. First and foremost, the DEA measures are relative measures in the sense that each observation is gauged only by comparison to the other observations in the sample. The "best practice" observations in the sample compose the frontier. Potential production of interior observations is gauged relative to the frontier.

Another characteristic (and perhaps the major problem) of the DEA approach results from the fact that the sample data are enveloped by a deterministic frontier. Consequently, the entire deviation of an observation from the frontier is attributed to inefficiency. Because the frontier is nonstochastic, no accommodation is made for environmental heterogeneity, random external shocks, and measurement error. All sorts of influences, favorable and unfavorable, beyond the control of the production unit are lumped together with inefficiency and included in

1. The solution to the LP programming problems identifies the observations to which an inefficient observation is compared. These comparisons are provided in appendix C.

the measure of inefficiency. Obviously, this can cause an over- or understatement of the true extent of inefficiency, unless there is a complete list of accurately measured variables, including all exogenous conditions or environmental variables. If a complete list of accurately measured inputs and outputs is available, however, the DEA approach provides an upper bound to the true but unknown efficiencies. (This is because it constructs the smallest possible production possibilities set based on the data.) Furthermore, since the whole approach is nonstochastic, there is no way of making probability statements about the shape and placement of the frontier or about the inefficiencies relative to the frontier.

THE STATISTICAL APPROACH

The statistical technique used here was first proposed by Aigner, Lovell, and Schmidt [17] and has been extended by Jondrow, et al., [18] among others. The first step is to specify a parametric form of the production relation given in equation 1. The parametric specification for this analysis is the linear specification:

$$y_i = \alpha_0 + \sum_{j=1}^n \alpha_j X_{ij} + e_i, \quad (2)$$

where the subscript $i = 1, \dots, k$ refers to the i th (year-district) observation, y_i is the output, the number of the enlistment contracts, and the X_{ij} is a measure of the j th independent variables. The unknown parameter vector to be estimated is denoted by $\alpha = [\alpha_0, \dots, \alpha_n]$, and e_i is the stochastic disturbance term. The specification of the production frontier and estimation of the maximal output, rather than mean output, is embodied in the specification of this disturbance term.

The stochastic frontier explicitly recognizes that a district's production may be influenced by random shocks (variations in the environment) that are not controlled for in the DEA specification. Some potential omitted inputs of particular importance have been discussed. The stochastic specification allows for the variation in output associated with measurement errors or omitted variables to be either positive or negative, rather than strictly negative. The error term in the specification is assumed to be composed of two parts. The first is a symmetric error that allows the frontier measurement to vary randomly across observations. It is the usual statistical "noise" in econometric work. The second component is one-sided, i.e., negative, and is intended to model the maximal nature of the production frontier.¹

1. An alternative statistical method is pursued in appendix D.

This model can be estimated by maximum likelihood techniques using the limited dependent variable (LIMDEP) computer package [19]. The error components are specified as follows:

$$e_i = u_i + v_i , \quad (3)$$

where e_i is the residual made up of the sum of a normally distributed error $u \sim N(0, \sigma_u^2)$ and a half normal inefficiency error $v \sim -|N(0, \sigma_v^2)|$. Reference [18] develops formulas for evaluating the mean and mode of the inefficiency component v_i , conditional on the observed value of e_i , for each observation in the sample. The mode calculation is

$$\begin{aligned} M(v_i | e_i) &= -e_i(\sigma_v^2 / \sigma^2) \quad \text{if } e_i < 0 \\ &= 0 \quad \text{if } e_i \geq 0 \end{aligned} \quad (4)$$

where $\sigma^2 = \sigma_u^2 + \sigma_v^2$.

Given that the estimate of potential production reveals actual production to be less than potential, the mode of the inefficiency component is proportional to the prediction error. The required computation is easily carried out using the results of the LIMDEP estimation. See the LIMDEP manual, and [18] for details.

Only one input controllable by the Navy enters the production function; the rest are environmental variables. For this reason, issues related to input substitution do not explicitly arise. Other simple alternatives, including the logarithmic transformation of inputs, outputs, or both could have been used. Such transformations do affect the identification and magnitude of the estimated inefficiency component of the error. Sensitivity tests could be done to see how the results depend on the specific form of the parametric production function and transformations of the variable measurements.

The relative strength of the stochastic, parametric approach is in the stochastic interpretation of the error term. Unlike the DEA approach, the stochastic approach yields estimates of the magnitude of the technical inefficiency component separate from random fluctuations.

EMPIRICAL RESULTS

The empirical results are presented in two parts. First, the estimates of technical efficiency of the recruiting districts in producing enlistment contracts are presented and analyzed. The DEA and statistical (STAT) estimates are presented separately, and then the results are compared. Next, the consistency of goals across districts is evaluated by computing measures of technical efficiency where output is measured as contract objective rather than actual contracts produced.

CONTRACT TECHNICAL EFFICIENCY ANALYSIS

Table 4 presents the DEA and statistical (STAT) efficiency measure estimates by district and year. To reiterate, one output, the annual total number of A- and CU-cell contracts for the fiscal year, is specified. Five inputs or factors that are expected to influence the production process are included. These are number of recruiters on board, A- and CU-cell population, unemployment rate, percent of district population urbanized, and the index of relative military to civilian pay. The sample includes 164 observations, the operation of 41 districts observed over 4 years (1981, 1982, 1984, and 1985).

The DEA measures should be interpreted in light of the fact that the performance of each district operating in a given year is assessed relative to all other observations in the sample. Thus, each district can be compared to other districts operating in any year as well as to itself operating in a different year. In table 4, a value of 0.0 for the DEA measure represents efficient production. In this case, actual output is equal to maximum potential output (as defined by the best practice districts) so that lost potential output is zero.¹ For example, district 102 operating in 1981 produced at least as many contracts as districts with similar levels of inputs and operating environments. In 1981, district 101 is gauged inefficient. One minus the value DEA measure is 4.3 for district 101 in 1981. This indicates that this district could have produced about 4 percent more contracts (with the same number of recruiters working under the same conditions) if it had been operating as efficiently as the best practice in the sample.

Notice that for some districts gauged inefficient, the level of inefficiency varies across years. Moreover, some districts are gauged efficient in some years and inefficient in other years. This variation is also demonstrated in table 5 where descriptive statistics of the DEA

1. The DEA measure is the ratio of maximum output to actual output. One minus the measure (which is how the measure is presented) gives the percent of actual output lost due to inefficiency.

TABLE 4
DEA AND STATISTICAL (STAT) EFFICIENCY MEASURE RESULTS : POOLED DATA

DISTRICT	1981		1982		1984		1985	
	DEA	STAT	DEA	STAT	DEA	STAT	DEA	STAT
101	4.3	0.0	9.8	0.0	9.0	0.0	15.0	4.0
102	0.0	0.8	2.8	1.7	1.2	3.7	0.0	6.4
103	22.6	3.1	20.6	3.3	20.6	2.3	23.6	3.9
104	29.0	14.2	18.1	8.8	15.1	5.7	24.6	9.6
119	27.9	6.9	20.3	2.4	3.5	0.0	18.4	2.9
161	22.0	5.1	19.2	3.3	14.1	2.5	39.5	14.2
310	28.9	7.7	18.7	11.7	4.3	1.1	0.0	0.0
311	0.0	3.6	0.0	0.0	0.0	0.0	0.0	0.0
312	17.9	2.6	7.1	0.0	5.6	0.0	0.0	0.0
313	10.0	3.5	1.6	0.0	0.0	0.0	0.0	0.0
314	45.5	13.2	41.6	16.7	32.8	10.4	31.5	7.9
315	5.7	0.0	0.0	0.0	7.3	0.0	0.0	0.0
316	30.7	16.1	28.5	10.6	0.0	9.1	2.0	5.4
348	0.0	8.2	0.0	7.8	29.9	11.4	26.9	14.5
406	18.9	4.9	9.5	0.0	12.6	0.0	15.6	1.5
409	0.8	0.0	2.5	0.0	0.0	0.0	0.8	0.0
417	0.0	0.0	0.0	0.0	7.9	0.0	3.2	0.0
418	8.5	0.0	10.6	0.0	18.0	0.0	15.4	0.0
420	22.1	2.5	21.3	6.5	9.0	2.5	15.4	0.0
422	0.0	0.5	0.0	0.0	6.8	2.3	17.6	6.9
521	0.0	21.9	31.5	16.6	15.4	8.5	15.1	8.5
524	9.8	6.2	9.1	0.0	4.7	0.0	0.0	0.0
526	0.0	8.9	0.0	11.7	3.7	11.9	0.0	8.0
527	23.3	8.3	10.6	2.3	12.9	4.9	0.0	0.4
528	38.4	19.5	19.3	8.5	17.8	5.2	0.0	0.0
529	0.0	2.1	0.0	0.6	0.0	0.2	0.0	0.0
342	0.0	4.1	0.0	0.0	0.0	0.0	9.0	0.0
559	18.3	15.0	10.8	8.1	0.0	1.1	5.0	0.0
725	0.0	1.0	13.3	0.0	0.0	0.0	0.0	0.0
730	0.0	2.7	0.8	0.0	0.0	0.0	0.0	0.0
731	14.5	9.8	30.5	7.2	0.0	0.0	10.6	1.0
732	0.0	4.3	18.2	2.3	8.6	0.0	6.2	1.0
733	0.0	7.8	20.8	7.0	22.2	5.9	12.6	2.1
734	59.0	17.5	59.9	18.5	24.9	7.9	20.8	7.4
746	0.0	20.5	14.3	10.5	0.0	5.3	0.4	5.2
747	0.0	13.5	0.0	6.6	0.0	6.1	0.0	0.2
836	24.4	26.0	25.3	15.5	12.8	9.4	0.0	1.4
837	17.7	10.9	8.9	2.4	0.0	0.0	0.0	0.0
838	0.0	19.6	6.4	7.3	1.6	5.1	4.7	11.5
839	18.1	3.7	14.2	1.5	2.5	0.0	0.0	0.0
840	33.4	12.4	33.9	10.9	0.0	0.0	0.3	0.0

TABLE 5.
DEA EFFICIENCY MEASURE STATISTICS BY AREA

AREA	YEAR	MEAN	ST DEV	MAXIMUM	PERCENT EFFICIENT
AREA=1		15.9	10.3	39.5	6 %
	1981	17.6	12.4	29.0	17
	1982	15.1	7.2	20.6	0
	1984	10.6	7.4	20.6	0
	1985	20.2	13.0	39.5	17
AREA=3		11.8	14.6	45.5	41
	1981	17.3	16.5	45.5	25
	1982	12.2	15.8	41.6	38
	1984	10.0	13.5	32.8	38
	1985	7.5	13.4	31.5	63
AREA=4		9.0	7.6	22.1	21
	1981	8.4	10.0	22.1	33
	1982	7.3	8.3	21.3	33
	1984	9.0	6.0	18.0	17
	1985	11.3	7.3	17.6	0
AREA=5		8.0	10.1	38.4	47
	1981	11.2	14.3	38.4	50
	1982	10.2	11.0	31.5	38
	1984	6.8	7.4	17.8	38
	1985	3.7	5.8	15.1	63
AREA=7		10.5	15.8	59.9	47
	1981	9.2	20.8	59.0	75
	1982	19.7	19.1	59.9	13
	1984	7.0	10.7	24.9	63
	1985	6.3	7.8	20.8	38
AREA=8		10.2	11.6	33.9	30
	1981	18.7	12.2	33.4	20
	1982	17.7	11.6	33.9	0
	1984	3.4	5.4	12.8	40
	1985	1.0	2.1	4.7	60
TOTAL SAMPLE		10.8	12.3	59.9	34
	1981	13.5	14.9	59.0	39
	1982	13.7	13.3	59.9	22
	1984	7.9	9.0	32.8	34
	1985	8.2	10.5	39.5	41

measure are given for the observations grouped by recruiting area, within area by year, by year, and for the total sample. The average efficiency measure for the sample is 10.8. This suggests that, on average, the districts could have produced almost 11 percent more than actually produced had they been operating with technical efficiency. Based on the mean efficiency for the observations grouped by year, the districts operating in 1984 and 1985 operate more efficiently, on average, than the districts operating in 1981 and 1982. Lost output on average is about 8 percent in 1984 and 1985, where it is over 13 percent in both 1981 and 1982.¹

The average efficiency across areas varies considerably. Area 1 has the highest average inefficiency with almost 16 percent of output lost due to inefficiency. Area 1 does not have the highest average inefficiency in each year, however. Along with area 4, the relative productive efficiency of area 1 declined in 1985. Area 7 contains the most inefficient observation with the maximum efficiency measure of almost 60 percent. The average efficiency measure is computed with the efficient observations included. Area 1 could have a relatively high average because it has the lowest percent of districts rated efficient. Only two (8 percent) of the area 1 district-year observations are rated efficient, whereas the other areas have at least 20 percent (areas 5 and 7 have 47 percent) of the districts rated efficient. Areas 3, 5, 7, and 8 have the highest efficiency ratings in 1984 and 1985.

Fifty-six observations were gauged efficient with the DEA method. Except for 1982, between 34 and 41 percent (or 13 to 17 districts) are efficient in each year. Only 9 districts (of the 41) operating in 1982 were gauged efficient. This coincides with the low average efficiency in 1982. Table 6 lists the 56 efficient observations by year and by district. Only two districts, 311 and 529, are gauged efficient in every year.

Table 6 also contains information on the number of times an inefficient observation is compared to each efficient district. (Appendix B gives the complete list of comparison districts for each observation.) These frequencies also demonstrate the relative performance advantage of areas 3, 5, 7, and 8 in 1984 and 1985.

Like the DEA measures, the statistical estimates of technical efficiency (STAT) given in table 3 for each district by year are computed as one minus the ratio of estimated potential contracts to

1. This is due, in part, to a change between 1982 and 1984 regarding the quality distribution of new recruits. Effort was directed away from the non-high school diploma market after 1982. This change, by itself, would increase the sum of A- and CU-cell contracts for a given level of total recruiting effort.

TABLE 6
DISTRIBUTION OF COMPARISON DISTRICTS
BY YEAR

<u>Efficient district</u>	Number of times efficient district dominates other districts' performances ^a			
	<u>1981</u>	<u>1982</u>	<u>1984</u>	<u>1985</u>
102	22	--	--	4
310	--	--	--	5
311	0	0	26	1
312	--	--	--	40
313	--	--	0	2
315	--	12	--	8
316	--	--	4	--
348	2	4	--	--
409	--	--	18	--
417	0	61	--	--
422	10	18	--	--
521	1	--	--	--
524	--	--	--	0
526	3	0	--	1
527	--	--	--	19
528	--	--	--	17
529	8	0	18	5
542	1	14	10	--
559	--	--	7	--
725	6	--	6	--
730	1	--	7	--
731	--	--	20	--
732	0	--	--	--
733	0	--	--	--
746	1	--	8	--
747	0	0	3	--
836	--	--	--	11
837	--	--	4	10
838	1	--	--	--
839	--	--	--	16
840	--	--	20	--

a. A dash indicates that the district was not efficient in that year. Zero indicates the district was efficient, but no other district is compared in that year.

actual contracts. Potential contracts are computed for each observation by adding the estimated mode of the inefficiency component to actual contract production. Like the DEA measures, a value of 0.0 for the statistical measure is interpreted as technical efficiency.

Table 7 describes the distribution of the two measures. The extreme (minimum and maximum) values, the lower (Q1) and upper (Q3) quartiles (or twenty-fifth and seventy-fifth percentiles), and the median are given for all observations and for the observations grouped by fiscal year. The minimum and lower quartile values for the total sample and each year are all zero for both measures. The median, upper quartile, and maximum are always (for the total sample and each year) higher for the DEA measure. A consistently higher median value for the DEA measure indicates that the distribution of this measure is located to the right of the distribution of the statistical measure. For the inefficient observations, the DEA approach measures higher levels of inefficiency or more lost contract production due to deviations from the frontier production levels.

Table 7 also gives the Spearman correlation coefficient between the two measures for each year and for the total sample. The coefficient measures the degree of association between the two measures, with a value of zero indicating the two measures are unrelated, and a value of unity indicating perfect correlation. In each year and overall, the coefficient is significantly different from zero. Despite the differences in the estimated level of inefficiency under the two approaches, the way in which the observations are ranked by the two measures is similar.

Table 8 illustrates, in a different way, the similarity in efficiency rankings using the two approaches. The observations have been grouped by degree of efficiency under the two measures. The inefficient observations have been classified into low and high inefficiency groups using the sample means. Observations with DEA measures less than 10.8 are classified as having a low DEA inefficiency rating. A value above the mean receives a high DEA inefficiency rating. A similar classification of the observations based on a comparison of the statistical measure with its sample mean efficiency rating (4.8) are also given in table 8.

The column totals in table 8 give the frequency of each category using the DEA measure, and the row totals provide the distribution based on the statistical measure. The DEA classification has 56 observations efficient, 43 observations with low technical inefficiency, and the

TABLE 7
COMPARISON OF DEA AND STATISTICAL MEASURES

<u>Mean/ measure</u>	<u>Quartiles</u>					<u>Spearman corr. coeff. (prob > R)^a</u>
	<u>Min</u>	<u>Q1</u>	<u>Median</u>	<u>Q3</u>	<u>Max</u>	
1981						
DEA	0.0	0.0	9.8	22.9	59.0	
STAT	0.0	2.5	6.2	13.3	26.0	.340 (.0294)
1982						
DEA	0.0	1.2	10.6	20.4	59.9	
STAT	0.0	0.0	2.4	8.7	18.5	.638 (.0001)
1984						
DEA	0.0	0.0	4.7	13.5	32.8	
STAT	0.0	0.0	1.1	5.5	11.9	.450 (.0032)
1985						
DEA	0.0	0.0	2.0	15.4	39.5	
STAT	0.0	0.0	0.4	6.7	14.5	.591 (.0001)
Total						
DEA	0.0	0.0	7.2	18.3	59.9	
STAT	0.0	0.0	2.5	8.1	26.0	.502 (.0001)

a. The Spearman Rank correlation coefficient was chosen over the usual (Pearson) product moment correlation coefficient because it requires that the two variables be measured on an ordinal scale rather than on an equal-interval scale. The interpretation of the coefficient as a measure of association is the same. Namely, the coefficient vanishes where there is a complete lack of association (uncorrelated) and equals unity when the variables are perfectly correlated. The significance probabilities are given as the probability associated with the occurrence of a correlation as large as the one observed in the sample under the null hypothesis. The null hypothesis states that the two variables (in this case, efficiency measures) are unrelated in the population.

TABLE 8
CONTINGENCY TABLE FOR DEA AND STATISTICAL MEASURES

Statistical measure	DEA			Total
	Efficient (DEA = 0)	Low (DEA \leq 10.8)	High (DEA > 10.8)	
Efficient (STAT = 0)	27	25	4	56
Low (STAT \leq 4.8)	14	10	17	41
High (STAT > 4.8)	15	8	44	67
Total	56	43	65	164

Contingency coefficient = 0.464

χ^2 statistic = 44.88^a

a. The null hypothesis is that the contingency coefficient is zero. The χ^2 test statistic is used. It is computed as

$$\chi^2 = \sum_{i=1}^r \sum_{j=1}^k (O_{ij} - E_{ij})^2 / E_{ij},$$

where O_{ij} and E_{ij} are, respectively, the observed and expected number of observations in the i th row and j th column, r is number of rows, and k the number of columns. Under the null hypothesis the expected frequencies for each cell is computed as the product of the two common marginal totals divided by the number of observations. The null hypothesis is rejected if observed χ^2 is larger than expected for a given significance level.

remaining 65 observations with high inefficiency. The alternative (statistical) classification also has 56 efficient observations, although they are not the same ones. Of the 56 observations gauged efficient with the DEA approach, 27 are also gauged efficient with the statistical approach. Of the remaining 29 efficient in the DEA approach, 14 were classified with a low level of inefficiency in the statistical approach. For the 67 observations with high levels of inefficiency based on the statistical measure, 15 are labeled efficient with DEA, 44 of the 65 are classified as having a high level of inefficiency with both approaches. In 19 of the 164 cases (12 percent), the two methods disagree significantly with efficient performance by one measure being labeled highly inefficient by the other. When the DEA method classifies a district's performance as (highly) inefficient, it is unlikely that the statistical approach will find the district efficient. This is not true to the same degree when the statistical approach identifies a district as (highly) inefficient.

The contingency coefficient given in table 8 is one measure of association between the two efficiency criteria of the table. The coefficient is positive and significant. This suggests that the classifications based on the two measures are not independent and provides further evidence of the similarity in the way the two approaches gauge efficiency for the sample.

CONSISTENCY OF CONTRACT OBJECTIVES

With information on district goals or contract objectives, the DEA approach can be used to provide additional information to planners. By comparing the contract objectives of similar districts, the consistency of the allocation of objectives across districts can be assessed. Typically, recruiting performance is evaluated on the basis of goal attainment. Combining the relative measures of technical efficiency with observations of goal attainment provides additional information for more efficient allocation of contract objectives and resources across districts.

This section and the next analyze three measures of performance. Table 9 lists these measures for each district and fiscal year.² The first measure, labeled TE, is the DEA measure of technical efficiency. This measure is similar to the DEA measures discussed in the previous section in that the same output (total A- and CU-cell contracts) and set

1. This may be due to the "global" nature of the statistical measure, and the "local" nature of the DEA measure. DEA compares only similar districts; the statistical approach extrapolates across districts.
2. Data on contract objectives in 1981 were not available, and, therefore, 1981 is excluded from this analysis. Furthermore, since the data are not pooled across years, analysis of 1983 recruiting is included.

T A B L E 9
TECHNICAL EFFICIENCY (TE), GOAL EFFICIENCY (GE), AND GOAL ATTAINMENT (GOAL) RESULTS

	1982			1983			1984			1985		
	TE	GE	GOAL									
181	8.8	1.7	AT	19.4	8.6	AT	8.7	9.1	BG	10.8	4.3	BG
182	0.0	0.0	AT	0.0	0.0	AT	0.0	0.0	BG	0.0	0.0	BG
183	15.6	6.2	BG	2.5	6.6	AT	9.1	3.5	BG	20.6	0.0	BG
184	13.7	9.6	AT	3.6	1.6	AT	14.1	9.3	AT	21.5	4.4	BG
119	17.0	19.5	AT	2.2	9.5	AT	0.0	8.3	AT	16.7	9.8	BG
161	11.2	22.6	AT	8.1	11.2	AT	10.0	5.4	AT	34.4	6.4	BG
310	15.6	16.2	AT	0.0	1.3	AT	0.0	1.1	AT	0.0	1.5	AT
311	0.0	0.0	AT	0.0	0.0	AT	0.0	0.0	AT	0.0	0.0	BG
312	0.0	31.7	AT	0.0	0.0	AT	0.0	0.0	AT	0.0	0.0	AT
313	0.0	0.0	AT	0.0	0.0	AT	0.0	0.0	BG	0.0	0.0	AT
314	40.3	19.5	AT	21.4	16.5	AT	22.6	11.0	BG	24.1	12.7	AT
315	0.0	4.8	AT	0.0	0.0	AT	0.0	0.0	BG	0.0	0.0	BG
316	19.4	14.0	AT	0.0	0.0	BG	0.0	0.0	BG	0.0	0.0	BG
348	0.0	0.0	AT	0.0	0.0	AT	28.2	9.2	AT	0.0	0.0	BG
406	6.4	36.5	AT	10.3	24.0	AT	3.2	0.1	AT	8.2	0.0	BG
409	0.0	6.4	AT	0.0	0.0	AT	0.0	0.0	BG	0.0	0.0	BG
417	0.0	3.7	AT	0.0	16.5	AT	0.0	0.0	AT	0.0	0.0	BG
418	10.3	10.5	AT	9.7	14.6	AT	5.4	3.0	BG	9.2	0.0	BG
420	21.1	29.7	AT	3.0	21.4	AT	0.0	2.6	AT	0.0	2.5	BG
422	0.0	0.0	AT	0.0	0.0	AT	0.0	0.0	BG	0.0	0.0	BG
521	0.0	0.0	BG	0.0	0.0	AT	0.0	0.0	BG	0.0	0.0	BG
524	3.8	2.2	AT	0.0	3.9	AT	0.0	3.2	AT	0.0	0.0	AT
526	0.0	0.0	AT	0.0	0.0	AT	0.0	0.0	BG	0.0	0.0	BG
527	0.0	5.4	AT	8.1	5.3	AT	3.1	0.0	BG	0.0	0.0	BG
528	3.8	27.9	AT	6.2	10.2	AT	12.2	7.3	AT	0.0	0.0	AT
529	0.0	0.0	AT	0.0	0.0	AT	0.0	0.0	AT	0.0	0.0	BG
542	0.0	0.0	AT	0.0	6.8	AT	0.0	0.0	AT	2.2	0.0	BG
559	0.0	0.0	AT	0.0	0.0	AT	0.0	0.0	BG	0.0	0.0	AT
725	0.0	0.0	AT									
730	0.0	0.0	AT									
731	0.0	0.0	AT	0.0	0.0	AT	0.0	0.0	BG	0.0	0.0	AT
732	0.0	0.0	AT	9.7	11.3	AT	2.6	9.6	AT	0.0	0.0	BG
733	0.0	0.0	AT	8.9	0.0	AT	12.4	3.9	BG	10.4	0.0	BG
734	45.7	9.3	AT	16.4	0.3	AT	7.9	8.5	BG	8.9	0.0	AT
746	0.0	0.0	AT									
747	0.0	0.0	AT									
836	10.6	0.6	AT	11.6	0.0	AT	8.7	1.9	BG	0.0	2.2	AT
837	0.0	0.0	AT									
838	0.0	0.0	AT	0.0	0.0	AT	0.0	0.0	BG	0.0	0.0	AT
839	4.8	3.2	AT	6.3	0.0	AT	0.0	0.0	AT	0.0	0.0	AT
840	29.7	13.9	AT	8.4	0.0	AT	0.0	0.0	AT	0.0	3.2	AT

of inputs is specified. There is, however, one important difference between the measures. The TE measures discussed in this section are computed for each year separately. The DEA measures in the previous section were computed for the pooled (by year) sample. Thus, the efficiency of a district was gauged relative to all other districts operating in the same year and in other years as well as to itself operating in a different year. The TE measures in table 9 gauge the performance of a district relative to only the performance of other districts operating in that same year.

The second performance measure listed in table 9, labeled GE, is a DEA measure of goal efficiency. This measure differs from the TE measure in that the output specified is the active-duty contract objective. Thus, GE is the ratio of the maximum potential contract objective to the actual contract objective. The maximum potential contract objective is determined by the contract objectives of other similar districts. The third variable in table 9, labeled GOAL, is a binary variable that compares actual production to the goal. If the district attained or exceeded the contract objective, then GOAL = AT. Otherwise, GOAL = BG.

The contract objectives and recruiting resources (e.g., number of recruiters) are allocated among areas based on past production levels and the estimated relationship between past production levels, the level of resources, and indicators of the economic and demographic conditions. The net result should be that two districts operating in similar recruiting markets with the same number and type of recruiters should have similar contract objectives. Consistency of objectives depends on the appropriate appraisal of the recruiting environment. The ability to predict changes in the environment due to business cycle swings is also required.

The goal efficiency measures (GE) in table 9 are used to examine the consistency of the allocation of the contract objectives across districts. The measure gauges a district's actual contract objective relative to the maximum potential contract objective determined by the other districts in that year. If the measure is 0.0, the district's objective is consistent in that it is at least as large as other similar districts' objectives. On the other hand, if the measure is greater than 0.0, the contract objective is low relative to the contract objectives of other districts operating in a similar recruiting environment with similar resources. Note that a value of 0.0 of the GE measure does not necessarily mean that the district's contract objective was set efficiently, only that relative to the other similar districts, that district's objective was the maximum objective specified.

If each district's contract objective is determined solely by the characteristics of the recruiting environment included in the analysis, then the GE measure should be zero for all districts. An ordinary least squares regression of contract objectives on the five

characteristics of the environment for each fiscal year explained a minimum of 93 percent of the variation in the contract objectives. The fact that the variables used to compute GE explain much of the cross-section variation in contract objectives suggests that the characterization of the recruiting environment used to compute the GE measures is similar to that used to set contract objectives.

Tables 10 and 11 summarize the GE measures given in table 9. Table 10 gives the number of inefficient observations by fiscal year and area. The most apparent change is the decrease in the number of districts whose goals were gauged inefficient between 1982 and 1985. In 1982, over half of the districts (22) had contract objectives that were low relative to similar districts operating that year. Three years later, most districts' contract objectives were "in line" with other similar districts; only 9 districts had lower goals relative to other districts in that year. In each year, districts with inefficient goals were found within each area, although area 7 has the smallest proportion overall. Area 1 has the largest incidence of inconsistent (low) objectives.

TABLE 10

NUMBER OF OBSERVATIONS WITH
INEFFICIENT CONTRACT OBJECTIVES
BY YEAR AND AREA

<u>Area</u> <u>(number of obs.)</u>	<u>1982</u>	<u>1983</u>	<u>1984</u>	<u>1985</u>
1 (6)	5	5	5	4
3 (8)	5	2	3	2
4 (6)	5	4	3	1
5 (8)	3	4	2	0
7 (8)	1	2	3	0
8 (5)	3	0	1	2
Total	22	17	17	9

TABLE 11

DISTRICT ACTUAL AND EFFICIENT CONTRACT OBJECTIVES BY YEAR
(Where Different)

District	1982		1983		1984		1985	
	Actual	Efficient	Actual	Efficient	Actual	Efficient	Actual	Efficient
101	2,809	2,857	2,226	2,411	1,951	2,129	2,132	2,224
103	2,988	3,173	2,312	2,465	2,352	2,434	--	--
104	3,678	4,031	3,003	3,051	2,678	2,932	2,996	3,128
119	2,896	3,461	2,246	2,459	2,023	2,150	2,138	2,348
161	2,596	3,183	2,100	2,335	1,893	1,995	2,066	2,198
310	1,951	2,267	1,759	1,782	1,680	1,698	1,711	1,737
312	2,081	2,741	--	--	--	--	--	--
314	2,124	2,538	1,707	1,989	1,569	1,742	1,733	1,953
315	2,471	2,590	--	--	--	--	--	--
316	1,878	2,141	--	--	--	--	--	--
348	--	--	--	--	1,407	1,536	--	--
406	2,184	2,981	1,722	2,135	1,905	1,907	--	--
409	2,963	3,153	--	--	--	--	--	--
417	2,662	2,760	1,849	2,154	--	--	--	--
418	2,858	3,158	2,219	2,543	2,261	2,329	--	--
420	2,245	2,912	1,657	2,012	1,843	1,891	2,049	2,106
524	2,255	2,305	1,883	1,956	1,697	1,751	--	--
527	1,984	2,091	1,538	1,620	--	--	--	--
528	2,050	2,622	1,872	2,063	1,833	1,967	--	--
542	--	--	1,610	1,719	--	--	--	--
732	--	--	1,560	1,736	1,344	1,473	--	--
733	--	--	--	--	1,586	1,648	--	--
734	1,954	2,136	1,766	1,771	1,430	1,552	--	--
836	3,646	3,668	--	--	2,962	3,018	3,155	3,224
839	2,576	2,658	--	--	--	--	--	--
840	3,368	3,836	--	--	--	--	2,851	2,942
Average	2,555	2,875	1,943	2,129	1,907	2,009	2,315	2,429
[Average difference]	[320]		[187]		[102]		[114]	
No. inefficient	22		17		17		9	
Average TE	13.4		10.0		5.6		5.3	

For the districts classified as having inefficient contract objectives, table 11 lists the actual objective and the efficient or maximum objective determined by the method.¹ Also included are the average of these variables and the average of their difference (maximum contract objective minus actual contract objective). In 1982, the average difference is about 320 contracts. In 1985, when contract objectives were set more consistently across districts, the difference between the maximum and actual objectives for the 9 inefficient districts is, on average, 120 contracts.

1. Recall that the GE measure is one minus the ratio of the maximum objective to actual objective.

EVALUATING OBJECTIVES

Despite the fact that efficient contract objectives are imperfectly known and goals are sometimes inconsistently set across districts, the achievement of contract objectives plays an important role in evaluating district performance. The ability to attain the contract objective depends on whether contract objectives are consistent with resources allocated to a district and recruiting conditions. A consistent allocation of contract objectives is obtained only if the market conditions facing each district are correctly evaluated.

Districts not achieving their contract objective may nevertheless be as productive as similar districts that achieved their goal. Conversely, some districts that achieve their contract objectives may not be as productive as similar districts that did not. Using this information on the relation between performance and goal attainment may be valuable in allocating changes in district objectives.

To illustrate the use of comparing the two performance measures, the observations are divided into four groups based on goal performance and the technical efficiency measure. Table 12 gives the number of districts classified into each of four groups by year. In 1985, there are 2 districts with production above goal, but less production than other similar districts. They would have been candidates for goal increases. On the other hand, 14 districts were as productive as similar districts, but did not achieve goal. Their failure to meet goal is not associated with differences in productivity between them and those efficient districts that attained goal. The nine districts that were as productive and did not achieve their objectives deserve closer scrutiny.

TABLE 12

COMPARISON OF GOAL PERFORMANCE AND
TECHNICAL EFFICIENCY

	<u>Number efficient</u>	<u>Number inefficient</u>	<u>Average inefficiency</u>
1982			
Attained goal (39)	24	15	6.5
Below goal (2)	1	1	7.8
1983			
Attained goal (40)	23	17	3.7
Below goal (1)	1	0	0.0
1984			
Attained goal (22)	16	6	3.2
Below goal (19)	11	8	4.1
1985			
Attained goal (18)	16	2	1.8
Below goal (23)	14	9	5.8

CONCLUSIONS

This research has examined the relative performance of different recruiting districts and the consistency of recruiting objectives during fiscal years 1981 through 1985. The results can be summarized as follows:

- The consistency of enlistment contract goals assigned to districts improved remarkably between FY 1982 and FY 1985. The number of districts with goals lower than similar districts (as defined by economic and demographic characteristics of the districts) fell by nearly 60 percent. The average amount by which goals were lower fell by 64 percent. The only significant inconsistency is that area 1 districts are more likely to have lower goals than similar districts in other areas. This may reflect a relative difficulty of recruiting in the Northeast that is not captured in this analysis.
- The improvement in consistency of goaling over this period is reflected in more similar performance among similar districts. Fiscal years 1984 and 1985 show an improvement in average technical efficiency of about 5 percentage points relative to 1981 and 1982. This may be associated in part with a desired shift in the quality composition of enlistment contracts between 1982 and 1984.
- Districts in area 1 have been less effective in producing A- and CU-cell recruits than similar districts in other areas.
- A cross-classification of districts by technical efficiency and goal attainment can be used to identify where goals should be redistributed, if necessary. Those districts achieving their objectives but not producing as many enlistments as similar districts should be considered for larger goals. On the other hand, districts performing as well as other similar districts but not achieving their objectives are candidates for smaller goals. Districts that are neither performing as well as other districts nor achieving their objectives deserve special attention.
- Two different approaches to the measurement of Navy Recruiting District production potential, DEA and statistical, produced measurements that generally agree on the ranking of districts with respect to technically efficient production of A- and CU-cell enlistment contracts.

When the DEA procedure classifies a district as (highly) inefficient, it is likely that the statistical approach will find a qualitatively similar result; however, when the statistical method identifies a district as technically inefficient, it is less likely that the DEA approach will concur.

All analysis in this paper is based on a particular characterization of the recruiting environment. A number of potentially important factors have been omitted, including advertising and interservice competition, among others. Other research along these lines would examine the allocative efficiency of the recruit mix produced by different districts. Such analysis is complicated by the necessity to assign relative values to recruit types. Nevertheless, allocative efficiency may be more important than technical efficiency.

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APPENDIX A
THE RECRUITING DATA SET

APPENDIX A
RECRUITING DATA SET

This appendix contains the recruiting data set used. Tables A-1 through A-5 list all variables described in table 1 of the text by district and year (one table for each year 1981 through 1985). The variables are measured in the units specified in the text. Note that data on contract goals for FY 1981 were not available, and the GOAL variable is set to zero for that year.

TABLE A-1
1981 RECRUITING DATA SET

DISTRICT	ACCON	RTR	POP	UR	URBPCT	PAY	ATTN	GOAL
101	1444	99	130730	6.4	87.9	110.98	2698	0
102	2054	185	200242	6.1	84.7	104.91	4112	0
103	1439	104	120548	7.8	76.7	127.14	3150	0
104	1571	136	192604	7.6	100.0	111.29	3664	0
119	1292	103	129011	7.3	100.0	114.38	2808	0
161	1308	98	137652	7.2	99.0	109.64	2763	0
310	937	75	73873	9.4	67.3	115.43	2047	0
311	786	60	60774	7.8	63.2	119.52	1771	0
312	1475	119	110717	5.8	82.3	137.00	2609	0
313	912	81	71923	6.1	68.5	120.74	2233	0
314	946	79	93507	9.0	57.3	118.90	2140	0
315	1281	87	107254	6.4	54.1	125.86	2587	0
316	623	62	67148	6.2	69.8	123.30	1864	0
348	692	52	65703	7.0	92.3	123.30	2926	0
406	1021	67	95039	8.3	79.4	122.56	1957	0
409	1419	91	122708	6.4	88.1	111.74	3128	0
417	1522	95	121630	9.4	82.5	99.48	2805	0
418	1563	101	136218	8.6	74.7	105.71	2850	0
420	1168	75	110057	8.7	69.0	114.49	2229	0
422	2368	151	212367	12.2	83.3	95.90	4597	0
521	1427	145	203232	8.4	92.0	92.94	2712	0
524	1034	82	106395	8.6	58.2	102.24	2195	0
526	858	65	93096	9.0	45.8	107.55	1945	0
527	815	68	99729	5.6	58.7	116.64	1840	0
528	957	91	151986	5.8	60.3	108.37	1812	0
529	1271	98	140208	5.8	42.2	107.55	2135	0
542	1049	82	92236	9.5	63.5	100.19	1967	0
559	735	62	110485	7.7	68.6	97.44	1633	0
725	762	71	90242	5.3	68.9	93.04	1820	0
730	683	60	65835	6.2	56.1	110.52	1629	0
731	661	68	98978	4.9	81.3	94.88	1794	0
732	678	65	89490	4.7	86.5	97.84	1769	0
733	774	68	102120	5.5	53.3	107.35	1575	0
734	714	71	88943	8.0	69.7	102.55	1675	0
746	508	63	64487	6.6	80.5	102.24	1313	0
747	758	67	66408	8.6	31.2	124.32	1644	0
836	1424	157	220985	6.3	98.1	101.04	3785	0
837	1076	94	127126	8.1	61.4	99.73	2559	0
838	1820	183	246403	7.4	91.6	99.32	5570	0
839	1209	91	123070	8.5	70.3	98.82	2746	0
840	1342	119	159766	6.9	88.8	109.79	3755	0

*
The contract goal data for FY81 were not available and the value of GOAL is zero for all districts in that year.

TABLE A-2

1982 RECRUITING DATA SET

DISTRICT	ACCON	RTR	POP	UR	URBPCT	PAY	ATTN	GOAL
101	1495	102	128046	7.0	87.8	117.55	2858	2809
102	2096	151	196209	7.8	84.6	111.12	4352	4131
103	1492	100	117654	8.9	76.6	134.67	2954	2988
104	1776	140	186740	8.0	100.0	117.88	3974	3678
119	1447	95	125624	8.7	100.0	121.15	2970	2896
161	1351	88	134106	8.1	99.0	116.13	2666	2596
310	1043	77	72964	12.3	67.4	122.35	2156	1951
311	1009	63	59945	9.5	63.3	126.68	2124	1908
312	1687	118	110802	7.2	82.3	145.21	2237	2081
313	1196	83	71092	7.3	68.7	127.98	2547	2254
314	993	75	92370	11.3	57.3	126.03	2199	2124
315	1590	90	105977	8.4	54.2	133.40	2899	2471
316	811	66	66174	7.8	69.9	130.69	2012	1878
348	798	52	65898	8.3	92.2	130.69	3229	2818
406	1378	77	93312	10.1	79.4	131.29	2549	2184
409	1627	97	120527	7.7	88.0	119.69	3006	2963
417	1895	85	118421	12.2	82.3	106.56	3108	2662
418	1664	90	133425	11.1	74.6	113.23	3056	2858
420	1281	77	107219	12.0	68.8	122.64	2424	2245
422	2645	149	207353	14.5	83.1	102.73	5105	4660
521	1494	120	198299	10.3	92.0	99.56	3326	3373
524	1245	76	104283	9.8	58.1	109.51	2473	2255
526	900	61	91555	10.7	45.7	115.20	1858	1847
527	1021	68	98007	6.9	58.6	124.94	2036	1984
528	1157	77	149895	7.3	60.4	116.08	2165	2050
529	1328	85	137470	7.3	42.3	115.20	2778	2706
542	1383	77	90205	11.0	63.5	107.33	2479	2160
559	959	61	108540	10.1	68.5	104.37	1895	1742
725	860	66	90520	6.7	69.1	98.62	1885	1771
730	827	59	65702	7.2	56.4	117.15	1693	1629
731	767	70	98438	5.6	81.3	100.57	1824	1719
732	805	63	89694	6.2	86.7	103.71	1737	1644
733	870	71	101323	6.2	53.3	113.79	1940	1806
734	749	67	87957	9.1	69.9	108.69	1955	1954
746	666	65	63405	7.3	80.5	108.37	1640	1558
747	1004	69	65044	10.7	31.4	131.78	1965	1734
836	1561	126	217731	8.0	98.1	104.80	3692	3646
837	1352	92	126627	9.8	61.4	103.45	2917	2736
838	2161	153	245169	9.8	91.5	103.03	5223	4787
839	1388	89	122049	10.8	70.4	102.51	2917	2576
840	1503	116	160866	9.6	88.7	113.88	3651	3368

TABLE A-3

1983 RECRUITING DATA SET

DISTRICT	ACCON	RTR	POP	UR	URBPCT	PAY	ATTN	GOAL
101	1460	99	124990	7.1	87.6	115.81	2322	2220
102	2075	152	191191	7.4	84.6	109.47	3401	3301
103	1724	103	114552	10.8	76.5	132.67	2424	2312
104	1924	127	180149	8.8	100.0	116.13	3237	3003
119	1632	95	121712	8.9	100.0	119.38	2389	2246
161	1414	89	130241	8.2	99.0	114.41	2187	2100
310	1262	86	71611	13.8	67.4	120.73	1815	1759
311	1079	68	58576	10.3	63.5	125.00	1708	1635
312	1767	122	110184	8.4	82.4	143.29	2678	2522
313	1165	84	69629	7.6	68.9	126.29	1872	1838
314	1123	79	90592	12.7	57.4	124.38	1736	1707
315	1600	89	104305	9.6	54.3	131.63	2234	2177
316	838	68	64658	6.8	70.0	128.96	1516	1531
348	908	55	65464	9.5	92.0	128.96	1854	1815
406	1303	81	91153	11.6	79.5	129.83	1914	1722
409	1605	95	117997	7.1	87.9	118.36	2437	2360
417	1655	85	114658	13.8	82.3	105.38	2068	1849
418	1700	101	129969	11.9	74.6	111.98	2357	2219
420	1363	76	103920	16.2	68.6	121.28	1750	1657
422	2850	152	201120	15.1	83.0	101.59	3743	3652
521	1925	138	193186	11.8	92.0	98.46	3083	2997
524	1482	84	101735	11.9	58.0	108.50	2012	1883
526	953	64	89346	13.9	45.6	113.93	1364	1316
527	1018	70	95815	8.1	58.7	123.56	1568	1538
528	1384	87	147198	8.6	60.5	114.79	1961	1872
529	1307	83	133920	8.0	42.5	113.93	1829	1762
542	1232	72	87737	11.4	63.6	106.14	1686	1610
559	1151	64	106116	11.5	68.5	103.22	1605	1591
725	1090	69	90191	7.2	69.1	97.31	1696	1635
730	942	62	65245	8.9	56.6	115.59	1468	1440
731	975	68	98241	5.9	81.4	99.23	1620	1612
732	1063	70	90324	9.9	86.8	102.33	1685	1560
733	1174	83	99952	9.5	53.5	112.28	1918	1835
734	1057	75	86267	11.9	70.0	107.25	1818	1766
746	760	66	62757	9.1	80.6	106.93	1258	1211
747	1029	66	63003	12.4	31.6	130.03	1583	1508
836	1809	131	213627	9.5	98.0	103.07	3336	3303
837	1544	92	124907	10.7	61.4	101.73	2276	2199
838	2310	157	242555	10.5	91.5	101.32	3985	3694
839	1520	95	120331	11.1	70.6	100.81	2429	2258
840	1797	108	160734	10.7	88.7	112.00	2948	2818

TABLE A-4

1984 RECRUITING DATA SET

DISTRICT	ACCON	RTR	POP	UR	URBPCT	PAY	ATTN	GOAL
101	1214	87	121869	5.4	87.7	114.89	1888	1951
102	1638	124	186460	5.3	84.5	108.60	2745	2797
103	1421	100	111220	7.9	76.2	131.62	2219	2352
104	1572	110	173260	7.4	100.0	115.21	2683	2678
119	1395	83	118202	7.2	100.0	118.40	2045	2023
161	1155	79	126156	6.2	99.0	113.50	1914	1893
310	1138	77	69770	10.5	67.8	118.62	1726	1680
311	1011	68	57488	7.2	63.8	122.82	1594	1575
312	1648	112	109523	6.3	82.3	140.79	2556	2462
313	925	72	68144	6.0	69.2	124.09	1677	1712
314	950	71	88301	9.3	57.5	122.19	1564	1569
315	1312	88	102047	6.9	54.7	129.34	1992	2038
316	682	65	63734	5.3	70.8	126.71	1295	1534
348	755	65	64317	7.2	91.8	126.71	1477	1407
406	1248	77	88889	9.0	79.5	128.70	1965	1905
409	1315	85	115488	5.4	87.9	117.33	2064	2111
417	1434	76	110540	10.3	82.3	104.46	2074	1934
418	1437	90	126053	9.3	74.6	111.01	2137	2261
420	1360	75	100575	12.7	68.4	120.23	1899	1843
422	2150	145	194550	11.5	82.9	100.71	3278	3772
521	1649	129	187192	9.0	92.0	97.60	2753	3136
524	1136	71	99013	9.4	57.7	107.36	1733	1697
526	894	64	86885	10.9	45.4	112.94	1483	1558
527	852	62	93525	6.0	58.4	122.48	1298	1387
528	1175	80	143650	6.6	60.5	113.79	1852	1833
529	1093	67	130356	6.2	42.6	112.94	1562	1502
542	992	61	85315	8.1	63.8	105.21	1506	1505
559	906	56	103156	7.9	68.3	102.32	1421	1451
725	816	62	89386	5.7	69.6	95.61	1352	1307
730	740	55	64377	7.0	56.8	113.58	1107	1080
731	738	56	97360	4.3	81.4	97.50	1040	1123
732	947	66	89349	7.7	86.5	100.55	1408	1344
733	963	76	98414	7.7	53.7	110.32	1570	1586
734	943	74	84422	9.9	69.9	105.38	1419	1430
746	668	57	62187	7.6	80.7	105.07	1086	1086
747	909	65	60968	9.9	31.7	127.76	1501	1450
836	1617	122	208158	7.2	97.9	102.94	2702	2962
837	1271	76	122812	8.4	61.4	101.61	1960	1939
838	2089	145	238108	8.5	91.4	101.20	3411	3678
839	1489	92	118641	9.0	70.5	100.68	2173	2130
840	1758	106	159876	7.2	88.7	111.86	2868	2844

TABLE A-5
1985 RECRUITING DATA SET

DISTRICT	ACCON	RTR	POP	UR	URBPCT	PAY	ATTN	GOAL
101	1096	88	121018	5.0	87.5	114.02	1702	2132
102	1455	118	184460	4.3	84.3	107.78	2409	2982
103	1322	100	110106	7.0	75.8	130.63	2012	2565
104	1504	124	168700	6.8	100.0	114.34	2544	2996
119	1210	91	116868	6.1	100.0	117.51	1756	2138
161	932	86	123856	5.4	98.9	112.65	1566	2066
310	1169	82	67953	9.4	68.2	118.91	1791	1711
311	904	71	57603	6.6	64.2	123.12	1565	1605
312	1796	119	109889	5.8	82.1	141.13	2884	2664
313	962	77	67410	6.0	69.4	124.39	1730	1692
314	979	75	86133	8.6	57.5	122.49	1741	1733
315	1345	90	100110	5.9	55.2	129.65	2186	2261
316	709	66	64913	5.4	71.7	127.02	1411	1565
348	678	62	62547	6.8	91.5	127.02	1571	1736
406	1180	81	87639	7.9	79.4	129.24	1700	2188
409	1185	86	114471	4.8	87.9	117.82	1962	2172
417	1482	82	107234	9.4	82.3	104.90	2199	2284
418	1390	91	123044	8.3	74.5	111.47	2134	2440
420	1350	78	98056	10.9	68.2	120.73	1953	2049
422	1848	140	187817	10.3	82.8	101.13	2864	3646
521	1637	133	181772	8.6	92.0	98.01	2727	3005
524	1264	85	97049	8.8	57.3	107.81	2044	2022
526	906	63	84566	10.1	45.2	113.41	1519	1630
527	873	59	92227	5.4	58.1	122.99	1428	1509
528	1351	80	140802	6.0	60.6	114.27	2083	2076
529	1180	72	128476	6.8	42.7	113.41	1709	1855
542	935	66	83747	7.7	64.1	105.65	1466	1748
559	989	64	100423	7.2	68.2	102.75	1628	1602
725	909	67	89085	5.7	70.2	95.84	1563	1560
730	817	61	64087	7.3	57.1	113.85	1320	1282
731	756	64	97311	4.8	81.5	97.74	1424	1375
732	894	63	87568	8.0	86.1	100.79	1484	1506
733	1042	79	97880	7.4	53.9	110.59	1770	1876
734	961	71	83305	10.6	69.8	105.64	1790	1762
746	690	58	62967	7.8	80.8	105.32	1269	1253
747	1038	70	59640	9.6	31.8	128.07	1696	1687
836	1942	139	203907	6.4	97.9	102.55	3210	3155
837	1327	83	119835	8.2	61.4	101.22	2160	2153
838	1933	164	234676	7.8	91.3	100.81	3738	3713
839	1504	92	116966	8.4	70.4	100.30	2353	2332
840	1746	114	159147	6.7	88.6	111.44	2852	2851

APPENDIX B
DEA LINEAR PROGRAMMING PROBLEMS

APPENDIX B

DEA LINEAR PROGRAMMING PROBLEMS

This appendix provides a further description of the DEA approach to the measurement of productive efficiency. The piecewise linear reference technology specification and linear programming problem are included.

The piecewise linear reference technology or frontier is constructed from the observed inputs and output of the recruiting districts in the sample. We assume that there are n inputs, denoted by $x = (x_1, x_2, \dots, x_n)$, one output, denoted by y , and k observations (or recruiting districts) of x and y , i.e., (x^i, y^i) , $i = 1, \dots, k$. Denote the matrix of observed inputs by X , where X is of dimension (k, n) , k observations and n inputs. Denote the k dimensional vector of observed outputs by Y . The construction of the piecewise linear technology requires the following restrictions:

(i) $y^i > 0$, $i = 1, \dots, k$, i.e., a positive output is produced by each activity (recruiting district)

(ii) $\sum_{i=1}^k x_j^i > 0$, $j = 1, \dots, n$, i.e., each input is utilized by at least one activity

(iii) $\sum_{j=1}^n x_j^i > 0$, $i = 1, \dots, k$, i.e., each activity uses at least one input.

Finally, let $z = [z_1, \dots, z_k]$ be a $(1 \times k)$ row vector representing the intensity (or activity) parameters for each of the k observations.

Following Fare, Grosskopf, and Lovell [2], the technology formed by the data (X and Y) can be written as:

$$T = \{(x, y): z \cdot Y \geq y \quad z \cdot x \leq x, \quad \sum_{i=1}^k z_i = 1\} . \quad (B-1)$$

1. For this application, x would consist of the inputs and environmental variables given on the right-hand side of equation 1. The output y is ACCON, the total A- and CU-cell contracts.

Computation of the degree of efficiency relative to the frontier is accomplished via linear programming (LP) techniques. The measure of technical efficiency relative to T for a given observation (x^0, y^0) is defined as:

$$DEA^0 = \max \{ \theta : (x^0, \theta y^0) \in T \} \quad (B-2)$$

and is computed for that observation, by solving the following LP problem:

$$\begin{aligned} DEA^0 &= \text{maximize } \theta \\ &\theta, z \end{aligned}$$

$$\text{s.t. } z \cdot Y \geq \theta y^0 \quad (B-3)$$

$$z \cdot X \leq x^0$$

$$\sum_{i=1}^k z_i = 1$$

$$\theta, z_i \geq 0, i = 1, \dots, k.$$

APPENDIX C

**DESCRIPTION AND LISTING OF
DEA COMPARISON DISTRICTS**

APPENDIX C
DESCRIPTION AND LISTING OF
DEA COMPARISON DISTRICTS

The solution to the linear programming problem indicates to which districts on the reference frontier an inefficient observation is compared. The optimal basic variables, i.e., the $z_i \neq 0$ in the optimal solution of each LP problem, determines a "best practice" subset of recruiting districts to which the district's performance is gauged. For each district, the efficient subset, in which that district's efficiency is gauged, is given by the set of z_i^* in the optimal basic solution. Tables C-1 through C-4 provide the computed efficiency measure and set of comparison observations for each district by year. The efficiency measure listed is the solution to the LP problem and gives the ratio of efficient to actual contracts rather than percent of actual contracts lost due to inefficiency as was presented in the text. The comparison districts are identified by year of operation and district number. For example, district 101 in 1981 is gauged inefficient with a computed efficiency measure of 1.043. This district is gauged inefficient relative to five "similar" districts. Only one district (102) was compared in FY 1981, one in 1984 (840), and three in 1985 (districts 312, 725, and 839). The comparison year-district observations are efficient observations (see table 3 of the text) that compose the facet of the efficient frontier to which district 81-101 is compared. These districts that the z_i^* identify together generate the efficient facet or comparison group of the reference technology to which the district is compared.

TABLE C-1

DISTRICT COMPARISON DISTRICTS FOR 1981 MEASURES

DISTRICT	DEA MEASURE	COMPARISON DISTRICTS (YEAR-DISTRICT)				
101	1.043	81-102	84-840	85-312	85-725	85-839
102	1.000	81-102				
103	1.226	82-315	82-417	82-422	85-312	85-528
104	1.290	81-102	82-422	84-840	85-312	
119	1.279	84-409	84-840	85-312	85-725	85-839
161	1.220	84-409	84-840	85-312	85-725	85-839
310	1.289	82-417	82-542	84-311	85-310	
311	1.000	81-311				
312	1.179	81-102	84-731	85-312	85-725	
313	1.100	85-311	85-312	85-313	85-315	85-725
314	1.455	82-315	82-417	84-311	84-529	85-725
315	1.057	82-315	82-417	85-315	85-528	85-529
316	1.307	81-348	84-311	84-316	84-730	84-731
348	1.000	81-348				
406	1.189	82-348	82-417	84-311	85-527	
409	1.008	81-409	84-840	85-312	85-725	85-839
417	1.000	81-417				
418	1.085	81-102	81-529	82-417	85-312	85-528
420	1.221	82-417	84-529	85-315	85-527	85-528
422	1.000	81-422				
521	1.000	81-521				
524	1.098	81-526	81-529	81-542	81-725	85-837
526	1.000	81-526				
527	1.233	81-529	84-529	84-731	85-315	85-527
528	1.384	81-102	81-529	84-731	85-528	85-725
529	1.000	81-529				
542	1.000	81-542				
559	1.183	84-529	84-559	84-725	84-837	
725	1.000	81-725				
730	1.000	81-730				
731	1.145	81-102	81-725	84-731		
732	1.000	81-732				
733	1.000	81-733				
734	1.590	82-417	82-542	84-311	84-542	84-746
746	1.000	81-746				
747	1.000	81-747				
836	1.244	81-521	81-725	85-836		
837	1.177	81-422	81-529	81-725	85-837	
838	1.000	81-838				
839	1.181	81-422	84-837	85-725	85-837	85-839
840	1.334	81-102	84-840	85-312	85-725	85-839

TABLE C-2
DISTRICT COMPARISON DISTRICTS FOR 1982 MEASURES

DISTRICT	DEA MEASURE	COMPARISON DISTRICTS (YEAR-DISTRICT)				
101	1.098	82-417	84-409	84-840	85-312	85-839
102	1.028	81-102	82-422	85-312		
103	1.206	82-315	82-417	82-422	85-312	
104	1.181	81-102	82-422	84-840	85-312	
119	1.203	82-417	84-840	85-312	85-528	
161	1.192	82-417	84-840	85-312	85-528	
310	1.187	82-417	84-311	85-310	85-312	85-747
311	1.000	82-311				
312	1.071	82-417	85-312			
313	1.016	84-311	85-310	85-312	85-747	
314	1.416	82-417	84-529	84-559	84-747	
315	1.000	82-315				
316	1.285	82-348	82-417	84-311	84-730	85-527
348	1.000	82-348				
406	1.095	82-348	82-417	84-311	85-527	
409	1.025	82-417	84-409	84-840	85-312	85-839
417	1.000	82-417				
418	1.106	82-315	82-417	82-422	85-312	85-528
420	1.213	82-417	84-529	84-559	84-747	
422	1.000	82-422				
521	1.315	81-422	82-417	84-731	85-836	
524	1.091	82-417	82-542	84-529	85-529	85-747
526	1.000	82-526				
527	1.106	82-315	82-417	84-529	85-527	85-747
528	1.193	82-417	84-529	84-731	85-528	
529	1.000	82-529				
542	1.000	82-542				
559	1.108	82-417	84-529	84-559		
725	1.133	82-417	82-542	84-542	84-725	84-837
730	1.008	82-417	84-311	84-730	85-527	85-747
731	1.305	82-417	84-409	84-731	85-725	85-839
732	1.182	82-417	84-311	84-542	84-731	85-725
733	1.208	81-730	84-311	84-529	85-315	85-725
734	1.599	82-417	84-311	84-542	84-730	84-746
746	1.143	81-746	84-311	84-746	85-725	
747	1.000	82-747				
836	1.253	82-417	82-422	84-840	85-836	
837	1.089	81-529	82-422	82-542	85-837	85-839
838	1.064	81-102	81-422	82-422		
839	1.142	82-417	82-422	82-542	85-837	85-839
840	1.339	82-417	82-422	84-840	85-312	

TABLE C-3

DISTRICT COMPARISON DISTRICTS FOR 1984 MEASURES

DISTRICT	DEA MEASURE	COMPARISON DISTRICTS (YEAR-DISTRICT)				
101	1.090	84-409	84-731	85-102	85-528	85-836
102	1.012	81-102	85-102	85-312	85-528	85-836
103	1.206	82-315	82-417	84-409	85-312	85-527
104	1.151	81-102	82-422	84-840	85-312	
119	1.035	82-417	84-409	85-527	85-528	
161	1.141	82-417	84-409	84-731	85-527	85-528
310	1.043	82-417	82-542	84-311	85-310	
311	1.000	84-311				
312	1.056	82-417	84-409	85-312	85-527	
313	1.000	84-311	84-316	84-731	85-312	85-313
314	1.328	82-417	84-529	84-730	85-527	85-747
315	1.073	82-315	84-311	84-529	85-315	85-725
316	1.000	84-316				
348	1.299	82-348	82-417	84-311	85-527	
406	1.126	82-417	84-311	85-312	85-527	
409	1.000	84-409				
417	1.079	82-417	84-542	84-559	84-725	84-731
418	1.180	81-102	81-529	82-417	85-312	85-528
420	1.090	82-417	84-559	84-730	84-747	
422	1.068	81-102	81-422	82-422	85-839	
521	1.154	81-422	81-725	85-725	85-836	
524	1.047	81-526	82-542	84-529	84-542	84-837
526	1.037	81-526	82-542	84-529	85-526	85-747
527	1.129	82-315	82-417	84-311	84-529	85-527
528	1.178	82-315	82-417	82-422	85-528	85-529
529	1.000	84-529				
542	1.000	84-542				
559	1.000	84-559				
725	1.000	84-725				
730	1.000	84-730				
731	1.000	84-731				
732	1.086	82-417	84-542	84-725	84-746	
733	1.222	82-417	85-315	85-529	85-725	85-747
734	1.249	82-542	84-746	85-725		85-839
746	1.000	84-746				
747	1.000	84-747				
836	1.128	82-417	84-731	84-840	85-836	
837	1.000	84-837				
838	1.016	81-102	81-422	82-422	85-836	
839	1.025	82-417	82-422	82-542	85-837	85-839
840	1.000	84-840				

TABLE C-4
DISTRICT COMPARISON DISTRICTS FOR 1985 MEASURES

DISTRICT	DEA MEASURE	COMPARISON DISTRICTS (YEAR-DISTRICT)				
101	1.150	81-102	84-409	84-731	85-102	85-312
102	1.000	85-102				
103	1.236	82-315	82-417	84-409	85-312	85-527
104	1.246	81-102	82-422	84-840	85-312	
119	1.184	82-417	84-409	84-840	85-312	85-839
161	1.395	84-409	84-731	84-840	85-528	85-836
310	1.000	85-310				
311	1.000	85-311				
312	1.000	85-312				
313	1.000	85-313				
314	1.315	82-315	82-417	84-311	84-529	85-527
315	1.000	85-315				
316	1.020	84-311	84-316	84-731	85-312	
348	1.269	81-348	84-311	84-316	84-731	
406	1.156	82-417	84-311	85-312	85-527	
409	1.008	84-409	84-731	85-102	85-312	
417	1.032	82-417	85-725	85-839		
418	1.154	82-417	84-409	84-840	85-312	85-528
420	1.154	82-417	84-311	84-730	85-527	85-747
422	1.176	81-102	81-422	82-422	85-839	
521	1.151	81-102	81-422	81-725	85-836	
524	1.000	85-524				
526	1.000	85-526				
527	1.000	85-527				
528	1.000	85-528				
529	1.000	85-529				
542	1.099	82-417	82-542	84-311	84-542	85-725
559	1.050	82-417	84-529	84-542	84-559	84-725
725	1.000	85-725				
730	1.000	85-730				
731	1.106	81-102	84-731	85-312	85-725	
732	1.062	82-417	84-542	84-725	84-746	
733	1.126	81-529	85-315	85-529	85-725	85-747
734	1.208	82-417	82-542	84-746	85-725	
746	1.004	82-542	84-746	85-310		
747	1.000	85-747				
836	1.000	85-836				
837	1.000	85-837				
838	1.047	81-102	81-422	81-838	85-836	
839	1.000	85-839				
840	1.003	81-102	84-409	84-840	85-312	85-725

APPENDIX D

**PRODUCTION FUNCTION ESTIMATION RESULTS
FOR THE STATISTICAL APPROACH**

APPENDIX D

PRODUCTION FUNCTION ESTIMATION RESULTS FOR THE STATISTICAL APPROACH

The statistical characteristics of the parametric, stochastic estimation and prediction of enlistment contracts are important for judging the confidence that may be placed in the predictions. Table D-1 presents the major statistics and parameter estimates associated with the linear specification. The R^2 is 0.83 in the OLS first stage of the two-stage procedure. The fit is thus reasonably good in an average sense. Maximum likelihood estimation of the parameters of the frontier converged quickly with only the constant term and population coefficient changing. The estimate of $\lambda = \frac{v}{\sigma}$ is 0.95, so that the standard deviation of inefficiency component is about the same as that of the random noise component. Average technical inefficiency is estimated from the formula in [17, p. 234]. It represents a loss of slightly less than one percent of enlistment contracts. The formulas in the text are used to evaluate the most likely value (mode) of the inefficiency component for each observation based on the results of this regression.

AN ALTERNATIVE STOCHASTIC PROCEDURE

Schmidt [D-1] suggests using the results of a one-way fixed effects model of cross-section, time-series variation in observed production to impute stochastic measures of technical inefficiency. In this approach, the regression equation is the same as equation 1 in the main text except for the inclusion of separate intercept terms for each of the districts. The estimation procedure is equivalent to OLS (as implemented in LIMDEP), but with district-specific fixed effects. These estimated fixed effects can be interpreted as average differences in productivity, other things being equal, assuming that the environmental variables have the same effect on output in all districts and at all times.

TABLE D-1

SUMMARY STATISTICS FOR STATISTICAL APPROACH
 (Dependent Variable: A- and CU-Cell Contracts)^a

<u>Variable</u>	<u>Coefficient</u>	<u>t-ratio</u>	<u>Mean of variable</u>
CONSTANT	-1,133.88	-5.35	1.00
POP	4.94	5.87	115.20
RTR	7.61	6.01	87.26
UR	54.33	7.69	7.87
PAY	625.96	4.18	1.13
URBPCT	79.90	0.67	0.73
LAMBDA (λ)	0.95	1.88	--
$\sigma^2 = \sigma_u^2 + \sigma_v^2$	194.83		
Average technical inefficiency	8.07		
log-likelihood	-1,079.7		
Mean of dependent variable	1,208.8		
Number of observations	164		

a. FY 1983 observations excluded from the sample.

The results of a one-way fixed-effects estimation of the production relation are given in table D-2. Schmidt [D-1] suggests measuring technical inefficiency as the difference between the maximum estimated fixed effect and each of the others. In this case, the measurement of technical inefficiency does not depend on any distributional assumptions regarding the skewness of the error term. Another advantage of this approach is the ready availability of standard statistical tests for the significance of the resulting technical inefficiency estimates.

The maximum fixed effect is about 220 recruits. The standard errors for the fixed effects are large (reflecting only four observations per district). They range from about 270 to 350. Only 6 districts have estimated fixed effects below -200 recruits per year, and they are predominantly (4 of 6) in area 3. This is surprising, because the four area 3 districts (310-313) were generally judged efficient in the other approaches. Perhaps this is evidence that even though they are efficient relative to the best practice of other districts, these districts had significant excess capacity and could have been goaled higher. Districts 161 and 420 are judged inefficient in all approaches, and closer inspection may yield fruitful analytical insights.

TABLE D-2
FIXED EFFECTS MODEL FOR CONTRACTS
(A-cell plus CU-cell)

Analysis of Variance

<u>Source</u>	<u>Variation</u>	<u>D.F.</u>	<u>Mean square</u>	<u>Proportion</u>
Within	0.1192E+08	123	0.9688E+05	0.474351
Between	0.1320E+08	40	0.3301E+06	0.525649
Total	0.2512E+08	163	0.1541E+06	

F test for homogeneity across individuals
 $F(40, 123) = 3.41$ Significance = 0.000

Ordinary least squares estimates

<u>Dependent variable</u>	<u>Contract</u>
Number of observations	164.00
Mean of dependent variable	1208.81
Std. dev. of dep. variable	392.57
Std. error of regression	142.33
R-squared	0.90
Adjusted R-squared	0.87

<u>Variable</u>	<u>Coefficient</u>	<u>Std. error</u>	<u>T-ratio (sig.level)</u>
POP	1.56	0.95	1.63 (0.10)
ONBOARD	10.69	--a	--a
URATE	2916.24	192.5	15.15 (0.00)
RELMILPY	118.91	--a	--a
URBPCT	-219.37	29.96	-7.32 (0.00)
Sigma	142.33	7.86	18.11 (0.00)

a. LIMDEP did not produce reliable estimates of confidence for these parameters.

TABLE D-2 (Continued)

F test for homogeneity across individuals
 (Estimated coefficients)
 $F(40,118) = 2.22$ Significance = 0.001

Estimated individual effects

<u>District</u>	<u>Coefficient</u>	<u>Std. error</u>	<u>T-ratio</u>
101	-91.00	316.97	-0.29
102	-160.38	316.60	-0.51
103	-178.63	316.29	-0.56
104	-90.33	324.59	-0.28
119	64.00	307.92	0.28
161	-339.65	291.20	-1.17
310	-283.93	284.14	-1.00
311	-254.79	272.20	-0.94
312	-366.14	287.10	-1.28
313	-463.52	293.28	-1.58
314	-68.05	325.42	-0.21
315	-78.58	340.55	-0.23
316	-79.70	336.62	-0.24
348	7.00	344.53	0.02
406	218.40	334.02	0.65
409	-52.52	319.84	-0.16
417	-34.84	311.22	-0.11
418	-162.27	292.37	-0.56
420	-251.62	297.63	-0.85
422	-167.43	319.29	-0.52
521	-82.13	314.05	-0.26
524	39.79	335.92	0.12
526	-31.59	322.49	-0.10
527	-180.28	323.09	-0.56
528	102.88	323.20	0.32
529	-47.25	316.21	-0.15
542	-143.45	306.65	-0.47
559	-86.46	287.36	-0.30
725	-152.05	290.83	-0.52
730	-138.12	304.13	-0.45
731	49.53	310.30	0.16
732	-129.13	322.38	-0.40
733	-70.34	320.88	-0.22
734	-147.85	314.20	-0.47
746	-10.80	324.66	-0.03
747	-86.92	314.20	-0.28
836	-65.83	302.53	-0.22
837	-61.60	285.04	-0.22
838	-144.86	289.01	-0.50
839	-133.58	303.92	-0.44
840	-7.55	298.71	-0.03

REFERENCE

[D-1] Peter Schmidt. "Frontier Production Functions." *Econometric Reviews* vol. 4, no. 2 (1985-1986): pp. 312-315

REPORT DOCUMENTATION PAGE

1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED		1b. RESTRICTIVE MARKINGS												
2a. SECURITY CLASSIFICATION AUTHORITY		3. DISTRIBUTION / AVAILABILITY OF REPORT APPROVED FOR PUBLIC RELEASE; DISTRIBUTION UNLIMITED.												
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE														
4. PERFORMING ORGANIZATION REPORT NUMBER(S) CRM 87-181 (Revised)		5. MONITORING ORGANIZATION REPORT NUMBER(S)												
6a. NAME OF PERFORMING ORGANIZATION Center for Naval Analyses	6b. OFFICE SYMBOL (if applicable) CNA	7a. NAME OF MONITORING ORGANIZATION Office of the Chief of Naval Operations (OP-01)												
6c. ADDRESS (City, State, and ZIP Code) 4401 Ford Avenue Alexandria, Virginia 22302-0268	7b. ADDRESS (City, State, and ZIP Code) Navy Department Washington, D.C. 20350-2000													
8a. NAME OF FUNDING / ORGANIZATION Office of Naval Research	8b. OFFICE SYMBOL (if applicable) ONR	9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER N00014-87-C-0001												
8c. ADDRESS (City, State, and ZIP Code) 800 North Quincy Street Arlington, Virginia 22217	10. SOURCE OF FUNDING NUMBERS PROGRAM ELEMENT NO. 65154N	PROJECT NO. R0148	TASK NO. WORK UNIT ACCESSION NO.											
11. TITLE (Include Security Classification) Recruiting Efficiency and Enlistment Objectives: An Empirical Analysis														
12. PERSONAL AUTHOR(S) Patricia E. Byrnes, Timothy W. Cooke														
13a. TYPE OF REPORT Final	13b. TIME COVERED FROM TO	14. DATE OF REPORT (Year, Month, Day) September 1987	15. PAGE COUNT 72											
16. SUPPLEMENTARY NOTATION														
17. COSATI CODES <table border="1"> <thead> <tr> <th>FIELD</th> <th>GROUP</th> <th>SUB-GROUP</th> </tr> </thead> <tbody> <tr> <td>05</td> <td>09</td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> </tr> <tr> <td></td> <td></td> <td></td> </tr> </tbody> </table>	FIELD	GROUP	SUB-GROUP	05	09								18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number) Enlistments, Linear Programming, Manpower, Military Requirements, Naval Personnel, Navy Recruiting Districts, Recruiters, Recruiting, Recruiting Quotas, Statistical Analysis. (SDW)	
FIELD	GROUP	SUB-GROUP												
05	09													
19. ABSTRACT (Continue on reverse if necessary and identify by block number)				<p>With increasing accession requirements and a more competitive recruiting environment, the size of the enlisted recruiting force has grown substantially. The Center for Naval Analyses was asked to provide analytical support to Commander, Navy Recruiting Command (CNRC), concerning ways to improve the return on this recruiting investment by examining the geographic allocation of recruiters, goals, and incentives. This research memorandum reports on the empirical analysis of three questions: (1) How do recruiting districts compare in terms of past production? (2) Are geographic differences in enlistment goals consistent with measured differences in recruiting market conditions? (3) How can the results be used to better evaluate district recruit production. <i>Key findings:</i></p>										
20. DISTRIBUTION / AVAILABILITY OF ABSTRACT <input type="checkbox"/> UNCLASSIFIED/UNLIMITED <input checked="" type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS		21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED												
22a. NAME OF RESPONSIBLE INDIVIDUAL Lcdr. Cashbaugh		22b. TELEPHONE (Include Area Code)		22c. OFFICE SYMBOL NRC-224										